Aalto University
School of Engineering

Energy efficient university campuses:

Influencing end-user behavior and end-user contribution to energy conservation

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Abstract

Environmental issues are constantly growing in importance and will most likely continue to do so due to increasing societal emphasis on reducing negative environmental effects. Environmental issues are important to society as a whole, as well as organizations and consumers. The built environment is the largest contributor to the negative environmental load. Finland is in many aspects a leader internationally when considering energy efficiency, especially when considering building services. However, the effect of building users and their activities have not been as widely studied as the technological aspects of energy efficiency. There seems to be a research gap when considering the psychological foundations of selecting intervention methods and trying to apply the most suitable intervention method for specific types of building end-users. Since there already exists much knowledge on how to improve the energy efficiency of buildings through technological improvements, it would be important to gain more knowledge related to improving end-user behavior.

The aim of this study is to identify methods for improving energy efficiency through behavioral change at university campuses. In addition, the users' effect on building energy efficiency and the factors affecting behavior are investigated through a literature review. The focus of the literature review is on examining different intervention methods and different aspects of improving the energy efficiency of buildings. The empirical study is based on a survey research design conducted at the University of Helsinki's Viikki campus and responses from a total of 196 building users in three buildings were obtained. The data is analyzed using three methods: correlation, factor and regression analyses. The potential energy saving in this case is situated somewhere between 0-20% depending on the success of the interventions. This is based on results of previous interventions and their reduction in energy consumption.

The findings of the study suggest that there are some variables that can help determine the most suitable intervention methods for building users. Community based social marketing, feedback and education were according to findings of this study the most suitable intervention methods for the University of Helsinki's Viikki campus. This research has laid a foundation for the continued study of the subject. Additionally, this research revealed that there are many aspects related to this field of study that need to be expanded.

Keywords Energy efficiency, end-user behavior, university campuses, interventions, environmental psychology

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Tiivistelmä

Ympäristöön liittyvien tekijöiden merkitys kasvaa jatkuvasti ja tullee kasvamaan jatkossakin johtuen suuremmasta yhteiskunnallisesta painotuksesta negatiivisten ympäristövaikutusten vähentämiseksi. Nämä tekijät ovat tärkeitä sekä organisaatioille että kuluttajille kokonaisuutta huomioitaessa. Rakennettu ympäristö on suurin ympäristöhaittojen aiheuttaja. Suomi on monesta näkökulmasta katsottuna kansainvälisesti energiatehokkuuden edelläkävijä, erityisesti rakennusteknisissä asioissa. Rakennusten käyttäjien ja heidän toimintansa vaikutuksia ei ole yhtä laajasti tutkittu kuin teknologian ja rakennustekniikan vaikutusta energiatehokkuuteen.

Tämän tutkimuksen tarkoitus on löytää tapoja energiatehokkuuden parantamiseksi käyttäjien käyttäytymisen kautta yliopistokampuksilla. Käyttäjien vaikutusta rakennuksen energiatehokkuuteen ja tekijöitä jotka vaikuttavat heidän käyttäytymiseen on tutkittu aikaisemmin. Miten rakennukset, niiden käyttö ja käyttäjien toiminta vaikuttavat rakennuksen kokonaisenergiakulutukseen tullaan myös tässä työssä perehtymään. Tutkimuksen teoreettinen osa toteutetaan kirjallisuuskatsauksena. Kirjallisuuskatselmuksen tarkoitus on luoda teoreettinen viitekehys, joka muodostaa perustan empiiriselle tutkimukselle. Empiirinen osio perustuu kyselyyn joka jaettiin Helsingin Yliopiston Viikin kampuksen tilankäyttäjille. Kertynyt aineisto on analysoitu käyttäen kolmea analyysimenetelmää: korrelaatio-, faktori- ja regressioanalyysi. Tämän tutkimuksen mukaisen potentiaalisen energiasäästön taso on 0-20 % välillä riippuen intervention onnistumisesta.

Tutkimuksen tuloksena löytyi muutama muuttuja joiden perusteella voidaan päätellä sopivimmat interventiometodit yliopistokampuksen tilankäyttäjille. Kuitenkin näyttää löytyvän tarvetta lisätutkimukselle, jossa huomioidaan psykoloogisia tekijöitä valittaessa interventiometodi ja valittaessa sopivin interventiometodi rakennusten erityyppisille käyttäjille. Tällä tutkimuksella on luotu perusta aiheen jatkotutkimuksille. Tutkimus paljasti monta tutkimuksen aiheeseen liittyvää tekijää jotka kaipaisivat lisätutkimusta.

Avainsanat Energiatehokkuus, loppukäyttäjien käyttäytyminen, yliopistokampukset, interventiot, ympäristöpsykologia

"Don't let us forget that the causes of human actions are usually immeasurably more complex and varied than our subsequent explanations of them."

— Fyodor Dostoyevsky

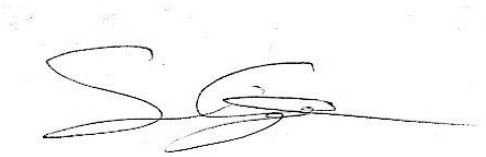
Preface

First of all I would also like to thank Jukka Kumara from Helsingin Yliopistokiinteistöt Oy and Veikko Martiskainen from Granlund Oy for giving me the opportunity write this thesis. I would also like to thank the rest of my co-workers at Granlund Oy, as well as the many who have provided me with help and information at the University of Helsinki.

I would also like to express my gratitude to my instructor Arto Huuskonen at Granlund Oy. He as provided invaluable help during the entire process of writing this thesis. At, moments I would probably have been lost without his help. He has also given me an introduction to the mysterious world of researcher and, I must admit, that it seems quite intriguing. Supervision provided by professor Seppo Junnila has also been greatly appreciated.

I also wish to thank my parents and my 'little' brother for their support and encouragement throughout my studies at Aalto, but especially during the process of this research. They have helped me both with encouragement and provided useful tips for writing the thesis. I can honestly say, I would not be where I am today without my family.

Finally, I would like to thank my fiancé for having patience and understanding with the thesis and me. Hopefully I can return the favor soon.



Espoo, 27.1.2015

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1 Introduction

In this chapter the background and importance of the study is described. The scope, aim and structure of the study are also described.

1.1 Background

Environmental issues are constantly growing in importance and will most likely continue to do so due to increasing societal emphasis on reducing negative environmental effects. Environmental issues are important to society as a whole, as well as organizations and consumers. Due to increasing expectations of consumers and other stakeholders, companies and organizations have to take environmental issues into account. Additionally, there is an increasing amount of legislation that demands companies and organizations to be environmentally responsible.

Environmental responsibility is a part of the brand image of many companies and organizations, and it is an important factor of competition for companies. Organizations strive to emphasize their pro-environmental aspects for example with environmental certifications. In general, eco-efficiency is also cost effective, which is important to organizations in regards to the profitability and efficiency of their activities.

The built environment is the largest contributor to the negative environmental load. The energy consumption of buildings and the activities that take place within the buildings are main contributors to the negative environmental load of the built environment. The construction and the use phases are the life cycle phases of buildings that account for the largest energy consumption. During the use phase, the use and maintenance of the buildings is what effects the energy consumption of the building. (Junnila & Nousiainen 2004)

Finland is in many aspects a leader internationally when considering energy efficiency, especially when considering building services. The effect of building users and their activities have not been as widely studied as the technological aspects of energy efficiency. There are, however, some studies within this subject area. For example, the saving potential of end-users in office buildings has been studied (Junnila 2007). Previous research of intervention methods related to energy efficiency has focused on specific intervention methods and energy reduction of the interventions, and not on the reasons why the methods have been successful or not.

At this moment, the most typical method of trying to reach behavioral change in consumers is education and information. Organizing energy saving weeks, or similar campaigns, seem to be the most common method to encourage improvements in energy consumption behavior. However, there may be many types of users in a building and they may all have different effects on the energy consumption in the building. For example, both students and researchers occupy the buildings of Helsingin yliopistokiinteistöt but they use the buildings quite differently. There have not been many studies on how different methods of encouraging better energy consumption behavior influences different user types. Most of the previous research focuses on the results of intervention methods instead

of why they obtain the savings and what factor influence the success of intervention methods. Often there is no clear reason for choosing a specific intervention method.

The utilization rate and the activities in the spaces also depend on the user type and their energy consuming behavior. The different manners in which users use the spaces and their possibilities to influence the energy consumption has to be considered when trying to find the most suitable methods for improving energy consuming behavior. By changing user behavior, lower energy consumption can be achieved and therefore also lower operating costs for companies. (Junnila 2009; World Business Council for Sustainable Development 2008; World Business Council for Sustainable Development 2009)

1.2 Aim

The aim of this study is to identify methods for improving energy efficiency through behavioral change at university campuses. The users' effect on building energy efficiency and the factors affecting behavior are also investigated. The methods through which the energy consuming behavior of users can be influenced will be emphasized in this study. (Figure 1)

The aim of this study can be stated by the following research questions:

RQ1: What factors related to the use of the building have an effect on its energy efficiency at university campuses based on literature? What is the energy saving potential of end-user activities at university campus buildings according to previous studies?

RQ2: What similarities or differences can be found between different users' perceptions of energy efficiency at university campuses?

RQ3: What methods do different users prefer for influencing the energy consuming behavior at university campuses?

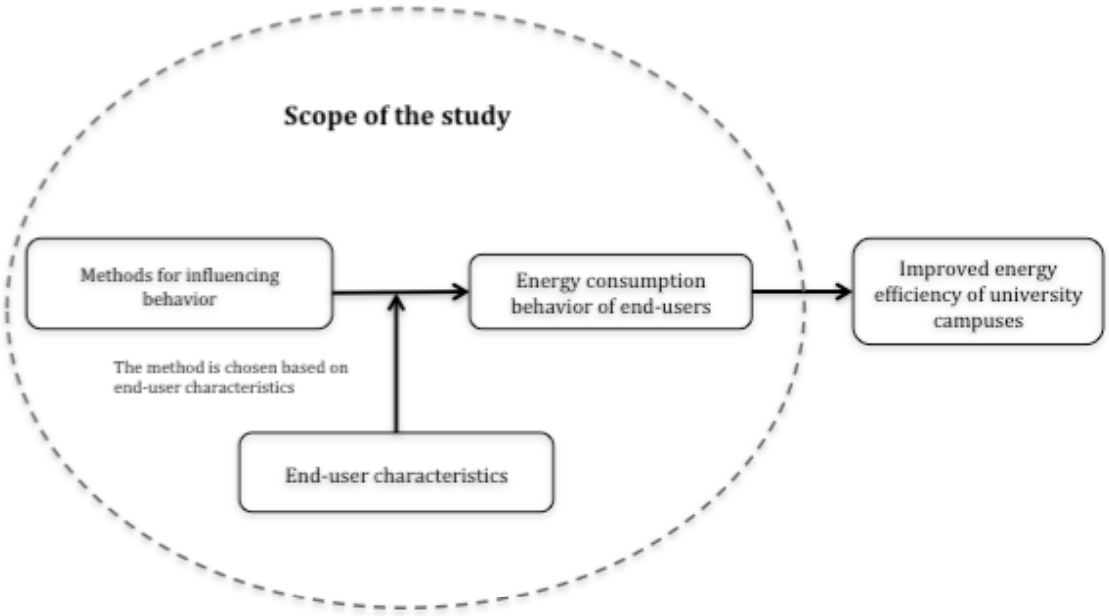

Figure 1 Frame of reference of the study

1.3 Scope of the Study

The study focuses on the different user types that can be identified on university campuses. These can be, for example, researchers, teaching staff, service staff and students. Three University of Helsinki buildings at the Viikki campus were studied. Based on existing energy consumption information and other information about the spaces, the energy consumption level and saving potential are assessed. The energy saving potential of the university buildings is assessed based on results obtained in the literature review and previous studies.

University campuses are interesting research subjects for this thesis for numerous reasons. They have not been as widely studied thus far in a similar context as this research. Additionally, a university campus is good setting to influence the energy users of the future and therefore the long-term energy consuming behavior can be improved at the future work places. Furthermore, some aspects of university energy consumption can be entirely or partly transferable to other organizations, e.g. business parks or office buildings. These types of buildings also have a large quantity of occupants and some of the buildings may have users that resemble the end-users at a university campus. Also, it can be assumed that there will be some differences among end-users at a university campus since there are several different user groups occupying the same spaces and buildings.

1.4 Structure of the Study

The study can be divided into three stages in accordance with the research questions (Figure 2). Firstly, the factors that have an impact on the energy efficiency of buildings are presented. Secondly, the user types that have an impact on the energy efficiency of university campuses are identified. Thirdly, the methods for improving energy consumption behaviors preferred by different user types will be identified.

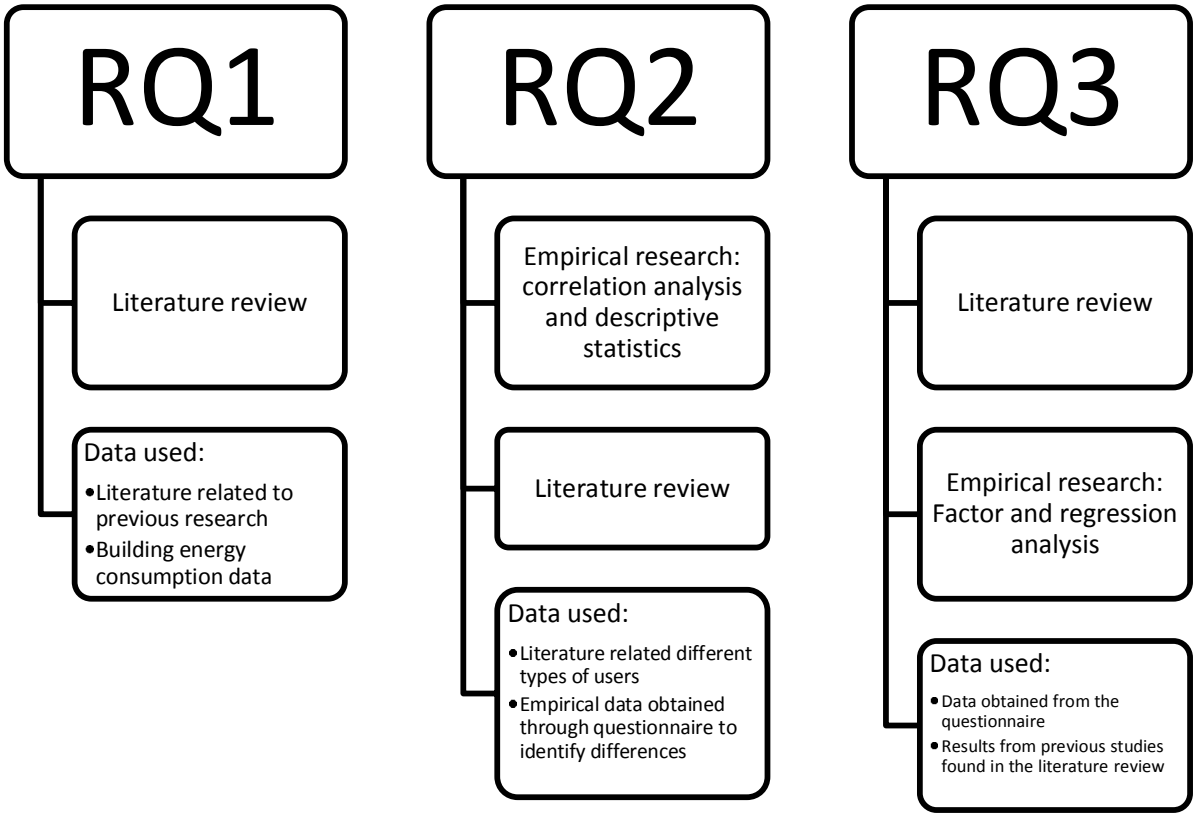

Figure 2 Methods used for answering the research questions

The aim of this study is to identify methods for improving energy efficiency through behavioral change at university campuses. More specifically, the users' effect on building energy efficiency and the factors affecting behavior are investigated. The theoretical part of the study will be conducted as a literature review. The aim of the literature review is to create a conceptual framework for the context-specific empirical analysis.

The empirical study consists of user survey. The user survey consists of a questionnaire aimed at building users at the Viikki campus of University of Helsinki. The aim of the empirical study is to create user profiles and find the most effective methods for influencing behavior for each profile.

2 Literature review

This chapter will focus on the energy efficiency of buildings and factors affecting the energy efficiency. How the occupants' behavior influences the energy efficiency of buildings will also be examined in this chapter.

2.1 Energy Efficiency of Buildings

The most cost effective way to reduce emissions is to improve energy. This relates to all aspects of society (Omer 2008). Everyone can improve energy efficiency; it is just a question of investment of either financial resources or and effort in changing behavior. By improving energy efficiency, all factors of sustainability can be improved. Improved energy efficiency can reduce negative effects on the environment, improve social aspects by indirectly creating jobs and economic benefits as consumers can use more of their resources for something else (Omer 2008). Improvements in energy efficiency can be obtained through two different ways: improved technology that consumes less energy or changed consumer behavior. (Henryson, Håkansson & Pyrko 2000) Energy efficiency can be defined as the ratio between the input of energy and its yield (CEN/CLC/TR 16103:2010). In other words, energy efficiency is maximizing the output with as minimal input of energy as possible. Energy efficiency of buildings can be expressed as kWh/m2 (Doukas, Nychtis & Psarras 2009).

Existing buildings are the area in which a difference can be made regarding energy efficiency and reducing impacts on the environment. By improving the energy efficiency of buildings the total energy consumption could be reduced by at least 20 %. This could lead to annual cost savings of around 60 billion € in the EU (Doukas et al. 2009). New buildings are often already energy efficient and meet the standards of today. They are also the buildings in which everyday actions may in fact make an impact. It is easier to improve something that is not working correctly, in comparison to a building that's functions and users are already as energy efficient as they can be. (Junnila 2009)

There is a need for services and operational models that promote energy efficiency. The (financial) advantages of the change in the operational models should benefit both end-users and owners of buildings. This would motivate both stakeholders to make energy efficiency a part of their operations. (Martinkauppi 2010)

2.1.1 Factors Affecting the Energy Efficiency of Buildings

The demand for electricity in buildings is determined by the need for energy to supply all the activities taking place in the building. Additionally, the activities and size of the building have an impact on the need for energy needed for heating and cooling of the spaces. (Vehviläinen et al. 2010) The energy efficiency of buildings is also largely dependent on how efficient the space use is and the activities that take place in the buildings (Martinkauppi 2010).

Figure 2 shows a simplified model of the factors that are a part of a building's energy consumption. This is the basis for knowing where energy consumption can be reduced. Improving technical features can minimize many factors of the total energy consumption.

However, there is already vast knowledge related to technical solutions. Changing the behavior of occupants and hence reducing their energy consumption is a far more complicated task.

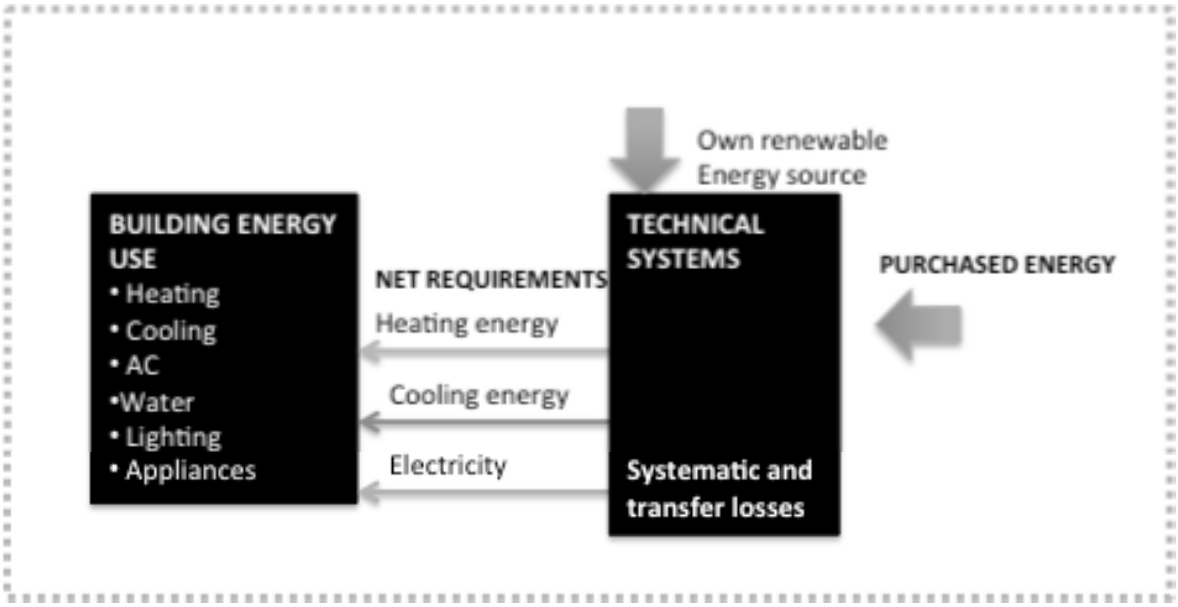

Figure 3 Building energy consumption factors (applied from Vehviläinen et al. 2010)

The following factors influence building energy consumption:

- Related to behavior
    1. User-related characteristics (e.g. user presence)
    2. Building occupants' behavior and activities
    3. Social and economic factors (these influence the behavior of the users)
- Related to other elements:
    1. Climate (e.g. outdoor air temperature)
    2. Building-related characteristics (e.g. type of building)
    3. Building services systems and operation (e.g. ventilation)
    4. Indoor environmental quality requirements

It can be stated that the factors within these two categories are interconnected and therefore should not be taken into account separately (Yu et al. 2011). The factors related to behavior all influence building energy requirements. By improving energy efficiency of behavior the building's energy requirements can me reduced. It may be difficult to measure the impact of social and economic factors on energy consumption. It is important to realize that these do influence the way a person behaves on a daily basis. It influences the ways in which people decide to behave.

A building has a long life cycle and therefore also a uses energy for a long time. The building lifecycle consists of four phases: production, construction, use and end of life. (Figure 4) The longest one of these phases is the use phase, but it does not alone affect the energy consumption of buildings. Depending on when and how a building is designed and constructed, the energy consumption of different phases can be very different. Especially old buildings that have not been constructed to meet today's requirements consume more energy during the use phase and therefore the use phase is where energy efficiency can be improved the most. (World Business Council for Sustainable Development 2008; Junnila 2007)

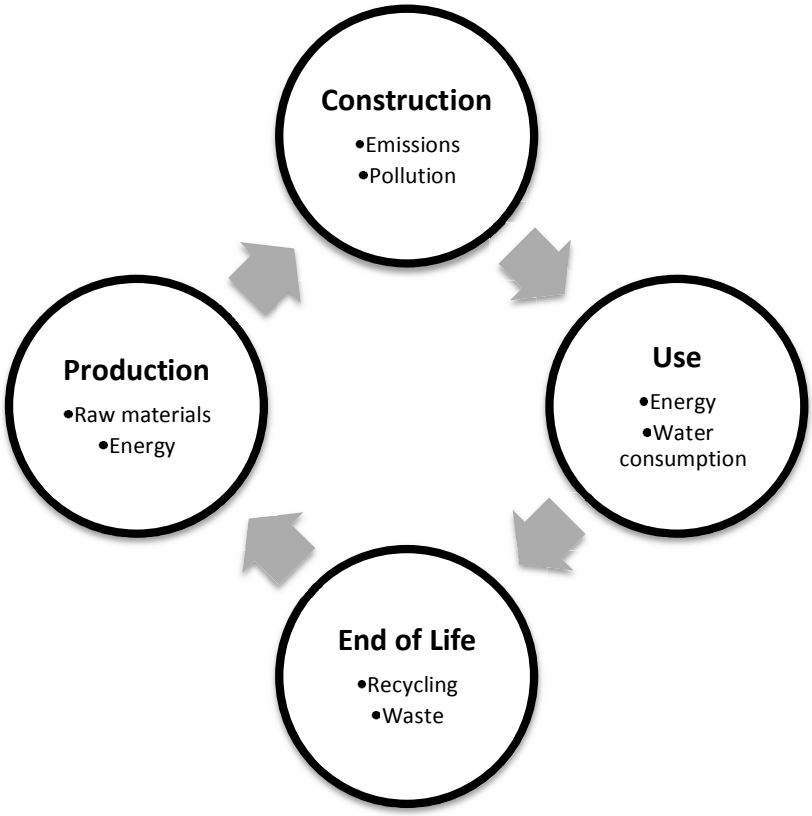

Figure 4 Building life cycle phases (applied from World Business Council for Sustainable Development 2008)

Most of a building's total life cycle energy consumption occurs during the operating (use) phase. Approximately 80% to 90% of a building's total energy consumption is consumed in the operation phase (Ramesh, Prakash & Shukla 2010; Cole & Kernan 1996; Omer 2008). This would indicate that this is the phase that should be focused on the most. Many of the decisions during the design of a building affect the energy efficiency of the building. But it is also crucial to use the building in an efficient manner. If the building is designed to be efficient, it can still be used inefficiently and as such emphasis should also be put on the efficient use of buildings and occupant behavior.

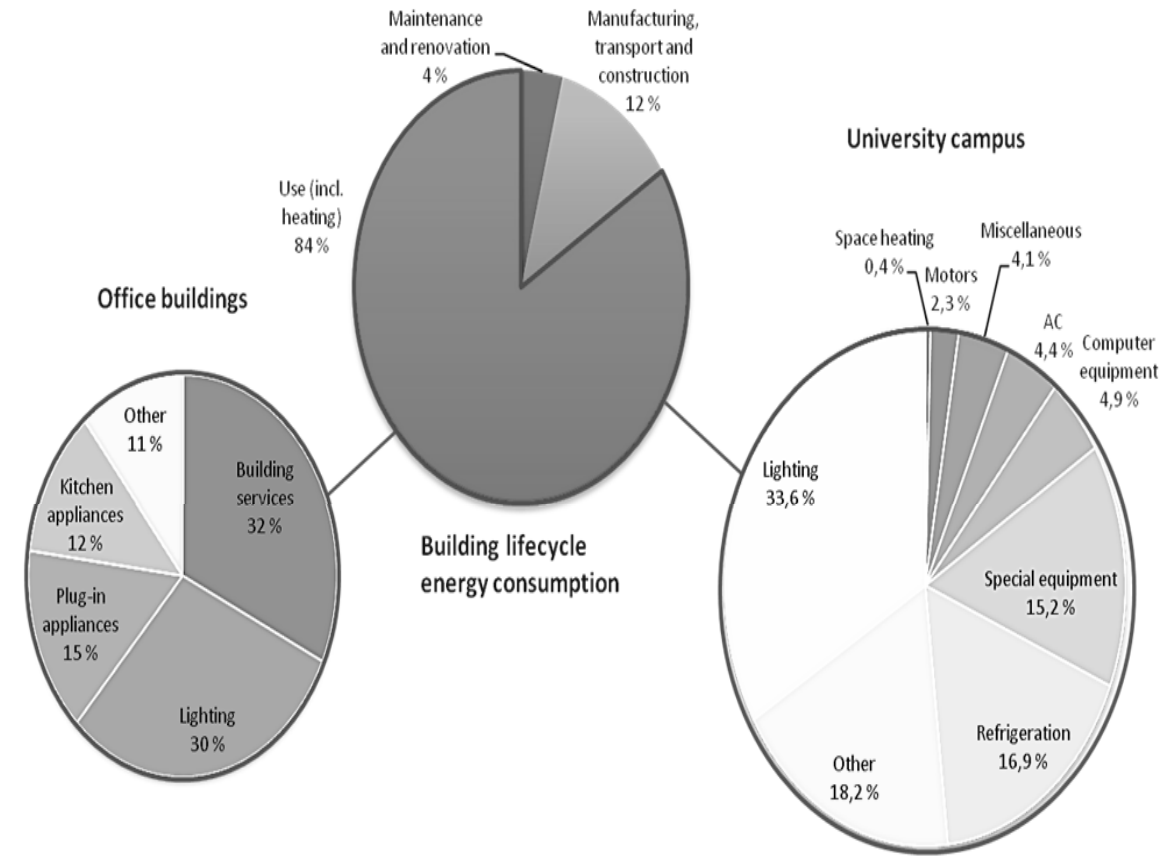

Figure 5 Examples of lifecycle energy consumption (World Business Council for Sustainable Development 2008; Escobedo et al. 2014; Nousiainen, Junnonen & Junnila 2006)

Most of a building's lifecycle energy is consumed by heating, cooling, lighting and ventilation. The energy consuming factors and their portion of the total energy consumption during the operating phase vary depending on many factors, e.g. building location and activities that occur in the building. In Canada, for example, the energy consumed by lighting, heating, cooling and ventilation of buildings stands for over 30 % of the national energy consumption. (Cole & Kernan 1996) This may be different in other countries with differing buildings, economies and climates. However, it clearly shows that the energy consumption during the operating phase of buildings is a substantial contributor to a country's energy consumption.

If comparing the energy usage of office buildings and the energy usage of a university campus (Figure 5), they do have slight differences. The percentages are not comparable, as one includes heating and cooling and the other does not (i.e. one depicts energy usage and the other electricity). However, what is visible from the comparison is that there are additional factors affecting the energy usage of the university campuses. Many university campuses have special equipment used for research, which is not often the case in offices. The study by Escobedo et al. (2014) found that 18.2% of energy was consumed on equipment that was not included in energy audits. The study does not specify what this equipment includes, but it stands for a significant portion of the energy consumption and therefore it would seem important to know exactly what equipment consumes the energy.

Also, it is difficult to reduce the energy consumption if the target of the reduction is not known.

When comparing the energy consumption of offices and universities, it can be noted that lighting consumes about 30% of the energy in both cases and is the largest factor of energy consumption in both cases. Other than that, any comparison between studies is hard to make as they have used different categories and have different factors that constitute the total energy consumption. More than 15% of the energy consumed at a university was consumed by special equipment. (Escobedo et al. 2014)This is equipment used for research and other specialized equipment. This proportion of energy consumed on special equipment is specific for the university in question and may be smaller or bigger at other universities depending on their fields of study and many other variables. Therefore, it is important to know what activities take place within universities in order to know what factors should be focused on when trying to improve energy efficiency. Often it would be beneficial to try to improve energy efficiency of the factors that contribute the most to the total energy consumption. It has to be acknowledged that in some cases it may not be reasonably possible to reduce energy consumption of certain factors as they are required for research, but at least energy wasting behavior related to the equipment should be minimized.

As universities are focused on research and otherwise are centers for innovation and education, a pressure has been put on them to act more environmentally friendly. Thus, many universities have to take action to become energy efficient. (Chan et al. 2012) Universities can take actions to both improve technological features of buildings and to try to change occupant behavior. It would also be a suitable place to imprint energy efficient behavior in the energy users of the future, the students. By integrating energy efficiency in the studies and activities at the universities the students could learn how to do things energy efficiently from the beginning.

Universities have often been overlooked in society as an important user of energy as well as being involved in operations that have an effect on the environment. For example, laboratories can often use extensive resources and produce an extensive amount of waste. Universities could be compared to large hospital complexes. (Alshuwaikhat & Abubakar 2008)

Universities are often the forerunners when it comes to research and development, and should therefore also set an example when it comes to energy efficiency (Alshuwaikhat & Abubakar 2008). This should not only be related to technology, as it is apparent that there are other issues relating to the energy consumption that impact the energy efficiency of a university campus. Behavioral change, which is related to for example sociology and psychology, should also be included as they are also important research fields.

It may be difficult to estimate the electricity and energy consumption by end use at universities in general. Universities have very different activities taking place in them. There is a difference in researching social phenomenon compared to medical research. The amount of energy required to conduct different types of research differs to a great extent. Laboratories with special equipment use more energy than offices. A study by Escobedo et al. (2014) found that lighting and refrigeration are the end use purposes that require most electricity. However, many universities are situated in very different climates and therefore can require more heating, in Finland for example. Hence, the end-use can be different.

2.1.2 End-User Effects on the Energy Efficiency of Buildings

It is sometimes difficult to identify the portion of the energy consumption that is related to end-users and the portion that is related to the building and technologies (Martinkauppi 2010). It is, however, known that both these do influence the total energy consumption. Due to difficulties with measuring it is in many cases hard to determine the exact portions of energy consumption these factors are responsible for. Efforts to reduce energy consumption can be made without knowing the influence of specific components. It would be beneficial to know to what extent a certain measure can reduce energy consumption, as time would not be wasted on measures with small impacts on total energy consumption.

Masoso and Grobler (2010) introduce the term *operational efficiency* relating to the energy consumption of the operations in the building. The study found that 50 % of the energy used in buildings, is consumed during non-working hours. This is mainly due to the users' energy wasting behavior. A large reduction in the energy consumed during the non-operating hours could have been eliminated if users would have taken some small actions, e.g. turning off the lights. In this situation savings could have been reached by minimal efforts. (Masoso & Grobler 2010) This would suggest that emphasis should be put on reducing this energy wasting behavior as it does not bring any additional productivity for organizations. This means that the energy consumed during non-working hours has a negative effect on energy efficiency and by eliminating the energy waste an improvement in energy efficiency could be reached. Masoso and Grobler (2010) suggested that minimal efforts would be required in order to reach these savings, and therefore it would seem to be an optimal starting point for reducing energy consumption. It would seem to be quite beneficial for organizations to start by minimizing the amount of energy that is wasted as it adds no value to their activities and, therefore, also influencing their efficiency.

2.1.3 Improving Energy Efficiency

Both technology and people affect the energy consumption and energy efficiency of buildings. Also, how people use the technology affects the energy consumption and energy efficiency. Zhivov et al. (2009) stated that how people use energy is just as important as the technology used.

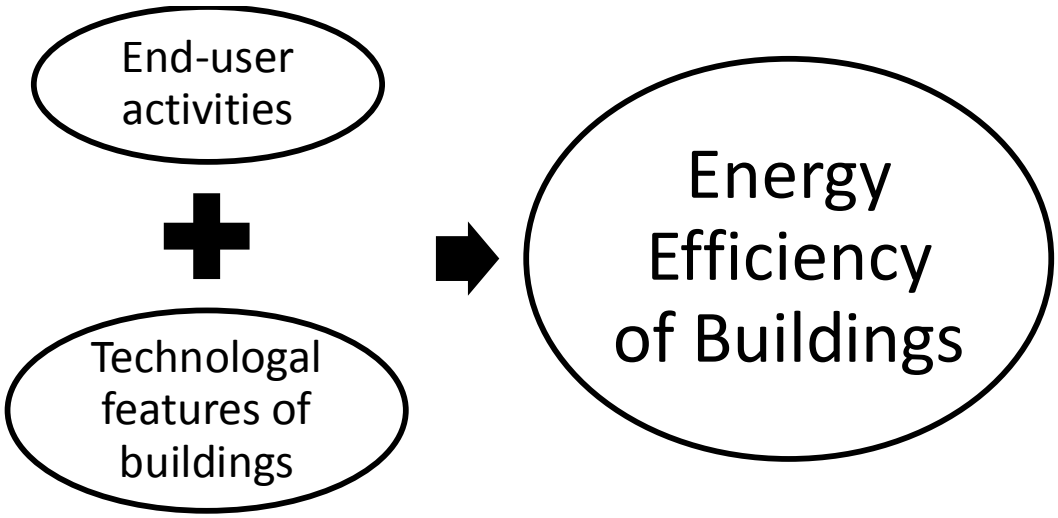

Figure 6 Improving Energy Efficiency of Buildings

Based on the literature review, the ways in which to improve building energy efficiency can be roughly divided into two categories:

1. Improving operational efficiency by either improving the energy consuming behavior of end-users or eliminating the effects of end-users by introducing automated systems in the building.

2. Improving the technical features of the building by investing in more energy efficient technology.

There is already much knowledge related to improving technological features of buildings, even zero-energy buildings exist. Hence, the only challenge related to technologies is reducing costs and ensuring that the best available technology is implemented when building new buildings and renovating old buildings.

People and behavior is a much more complex component of energy efficiency. People are different and the variables that influence behavior are numerous. There is perhaps no simple answer to how energy-consuming behavior can be improved, but some efforts in finding effective intervention methods have been made. The process of improving energy efficiency is often referred to as energy management.

2.1.4 Energy Management

Energy management is a process consisting of monitoring, valuating and conservation of energy in a building or organization. (Bennett & Armstrong Whiting 2005) Energy management is not about inventing something new, but about using knowledge and applying it in practice. Energy management does not mean only lowering the temperature, but obtaining energy efficiency through optimization. Since the energy costs have grown drastically during the past, awareness of energy consumption and the energy effectiveness of buildings is important. (Moran, Berman & Morasch 2005) Energy management can cover three different areas: supply of energy, energy efficiency and energy products and services (Bennett & Armstrong Whiting 2005).

For organizations, energy is a resource and a cost. Thus, energy consumption is often a part of the organizational strategy. Energy consumption relates directly to an organization's activities. The optimization of energy consumption should lead to decreased costs and more effective use of the resource. (Nousiainen et al. 2006) Therefore it is considered important for organizations to reduce energy consumption. According to a study conducted by Nousiainen and Junnila in 2005, 78% of the studied companies consider reduced energy consumption to be one of the environmental objectives that the companies emphasized. Demand for energy management can be expected to increase at close to the same rate that the price of energy raises. (Nousiainen & Junnila 2008)

The aspects that can be managed the most efficiently are the lighting and other electrical appliances. Also, the behavior and habits of the end-users are an important aspect of energy management. (Nousiainen et al. 2006) This would support the notion that it is important to focus on changing people's behavior. It is often considered more favorable to divide up the energy management process into smaller processes. It becomes simpler to control the individual processes and estimate their success (Sivill 2011). By applying this

philosophy it can be useful to conduct targeted interventions and a targeted group of people at one time. This may also result in better efficiency of intervention methods.

End-user-energy management is energy management where the user's behavioral patterns are managed in order to decrease the energy consumption. Use of BAS-systems (Building automation systems) can also be an alternative when users are not willing to change their behavioral pattern. BAS-systems are not dependent on the users' choices. Therefore, one can eliminate unnecessary energy consumption. This type of energy management requires none or very small investments and could therefore be favorable for organizations. (Junnila 2007; Wilkinson & Reed 2006)

The ESCO-method means that an ESCO-company carries the entire responsibility for a building's energy management. This method is based on an ESCO-company paying for all the investments required to improve energy efficiency of buildings. The ESCO-company then receives the savings in energy costs as payment for their services and investments. The ESCO-method is best suited for small companies that do not have possibility to make big investments. (Nousiainen et al. 2006)

Technical systems for energy management, also called BEMS-systems (Building Energy managements systems) can also be used in energy management (Doukas et al. 2009). With BEMS-systems, energy consumption can one monitor, analyze and to report the energy consumption. It is prerequisite that the system is used correctly in order for it to be effective. There are often some problems related to the use of such systems, and especially related to analyzing the data correctly. Often users have not received enough education and do not know how to use and analyze the system and information correctly. However, BEMS-systems can be useful in optimizing the use of the building and related services. Moreover, one can receive real time information about the building, its energy consumption and current situation. (Doukas et al. 2009; Nousiainen et al. 2006)

The best method depends on the building and its characteristics, as well as the organization. The user and the owner of the building should also be taken into consideration when the choice of which model of energy management will be used. (Nousiainen et al. 2006) The use of green property services can also be an option, which means that as well as managing energy consumption, the entire chain of services provided for the buildings serve to improve energy efficiency. (Määttänen 2014)

According to Nousiainen et al. (2006), the energy saving potential for office buildings is 1170 GWh per year in Finland. This potential is, however, only theoretical. In order to achieve the potential, the best available technology should be used. Nousiainen et al. (2006) state that financial savings of 11.6 % could be reached in Finland. Eight percent of the costs for heating and up to 3,6% of the costs caused by consumption of electricity could be eliminated through effective energy management. Energy consumed to heat buildings can, on national level, be decreased by 350 GWh, which corresponds to approximately 10-15 million euro. The corresponding number of electricity consumption is considerably smaller, closer to 2%, which corresponds to approximately 30 GWh. (Sivill 2011)

According to a study conducted by Junnila (2007) an office building's energy consumption can be reduced by approximately 20 % through energy management. In same study, it is mentioned that energy used for lighting and appliances could be reduced by 40-50 % if the

user behavior was changed. As the potential savings for changing user behavior do not require substantial investments, there should be no reason for organizations not to try them. However, changing behavior, through some sort of intervention, is not always easy and has not always been successfully done.

There are no studies available in how much the energy consumption at universities could be reduced. Therefore, it is difficult to estimate how much energy can be saved at universities. There are some similar activities at universities as at offices, however, there are many additional activities taking place at universities. Universities are also quite different from each other and there may be large differences in energy consumption when comparing, for example, universities that focus on social sciences and universities conducting research in which the method of inquiry is energy intensive.

According to Junnila (2007) the fact that energy costs usually are only a small portion of an organization's total costs can be an obstacle for successful energy management. The energy costs can stand for only approximately 1% of a company's total costs. Therefore, it may not seem important to reduce these costs. (Junnila 2007)

There is also a problem related to split incentives. If the owner pays for the electricity, then the user may not care about the energy consumption and vice versa. Thereby, both may be reluctant to make investments. In order to make the investment attractive, both stakeholders should benefit from the investment. The owner could for example receive a higher rent and the user could receive lower electricity bills. (Huovila 2007; World Business Council for Sustainable Development 2009)

Problems related to information are also an obstacle for successful energy management. There are two main problems related to information: interruptions in the information delivery and inadequate information. Interruptions in the information delivery means that the information does not reach everyone that needs or could use the information. A deficiency in information means that not enough information is available to the right people at the right time. (Määttänen, Jylhä & Junnila 2012)

Further obstacles for successful energy management are the skills and knowledge of facility managers. A study performed by Määttänen, Jylhä and Junnila (2012) demonstrates that facility managers in general have the skills and knowledge required for energy management, however, they are not used to the extent that they could. Often the organizations do not take advantage of their knowledge. Also, the high turnover of personnel affects the abilities to conduct energy management.

2.2 End-User Energy Consumption Behavior and Change

Behavior is a complex phenomenon that is influenced by many different variables. When considering energy related behavior, psychological, social and economic factors can influence behavior. (World Business Council for Sustainable Development 2008). When considering the aforementioned factors, it is clear that they are not simple factors in themselves. Energy consumers do not act completely rationally from an economic perspective. This means that the demand for energy is not based completely rational reasons and are often influenced by factors that are difficult to predict. There are many economic, psychological and social factors influencing the demand for energy (Breukers et al. 2011). It is difficult to predict how people behave. Behavior is often related to one

specific occasion and there are numerous factors that affect the specific behavior. This is called aggregation. Aggregation does not provide a sound base for predicting future behavior as it cannot predict future events and changes in the aggregated behavior disposition. (Ajzen 1991)

Ajzen's (1991) theory of planned behavior relates to someone having the intent to behave in a certain manner. The theory of planned behavior focuses on the person's motivations to behave in certain ways. This can include, for example, how hard the person is willing to work in order to achieve certain behavior. Background factors also have an impact on how people behave. (Figure 7)

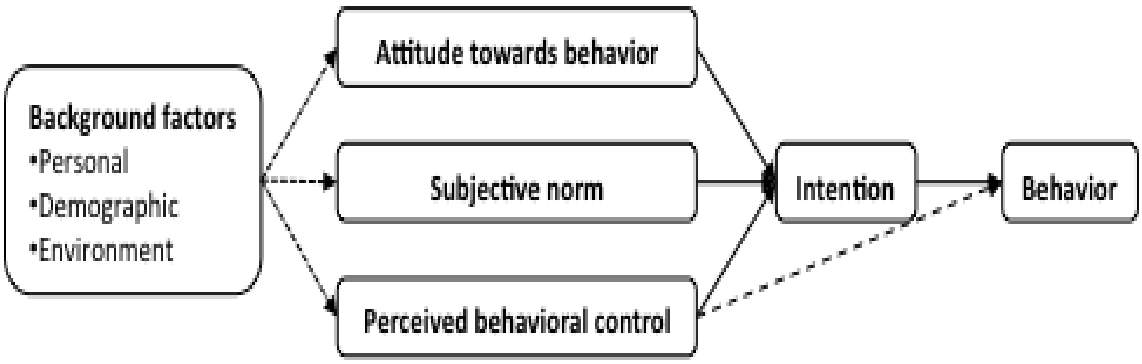

Figure 7 Theory of Planned Behavior (Ajzen 1991)

Perceived behavioral control means how easy or difficult a person considers it to be to behave in a certain way. Also, this can be stated as how high the probability of succeeding to behave in a certain manner is. Perceived control can be either very close or far from the actual control on a person's behavior. Intentions can be very important on predicting one's behavior if full control over behavior is assumed. Attitude towards behavior simply stands for how the person feels about the behavior in question, whether it is negative or positive. Subjective norm stands for how group pressure influences behavior. It depends on what the social norms of the group are. It is person's beliefs about the three factors that affect how the person behaves. People have beliefs related to all behavior, but are not capable of processing all of these beliefs at the same time. (Ajzen 1991)

A study by Poortinga, Steg and Vlek (2004) found that motivations alone are not enough to explain people's behavior. There are many other variable that are contribute to people's behavior. One of the variables is the context where the behavior takes place. This is also supports Ajzen's (1991) findings. According to Ajzen (1991) the environment also influences in which the behavior occurs also influences the behavior. This could indicate that the same person could behave differently in different settings. A person can, for example, be conscious of the cost of energy at home where people have to pay for energy themselves but at the workplace the person does not care about the cost as it does not directly affect the person in question. Based on this, the surrounding should also be taken into account.

2.2.1 Motivations for Behavioral Change

Motivations can be either extrinsic or intrinsic (Amabile 1993). One of these two factors motivates people to change their behavior (Chan et al. 2012). Extrinsic motivations comes from outside the person and are often related to how others perceive oneself, whereas, intrinsic motivation is driven by internal motivations such as enjoyment. Extrinsic motivations can be can be any outside motivator such as monetary reward or rewards in some other form. Internal motivators are often driven by a person's own values and what the person views as important, such as family. (Amabile 1993; Chan et al. 2012)There needs to be a distinction between these to in order to know which one of the motivators is more likely to influence a particular persons behavior.

A study by Bolderdijk et al. (2013) compares monetary and moral motives in pro-environmental behavior. It is often assumed that people need a monetary incentive in order to change their behavior. It is also clear that people do care about how they are viewed. According to the study, people expected a better outcome in regards to their own feelings about themselves if a message was delivered to them with biospheric motivations instead of economic motivations. (Bolderdijk et al. 2013) As such, the fact that moral motives do have an impact on behavior should not be neglected. The study does not find that economic motives are irrelevant, it simply states that the biospheric ones should not be discarded as they may be more effective when the monetary benefit of behavioral change is not as extensive or apparent (Bolderdijk et al. 2013). In the case of university buildings, this is an important piece of information, as there may not be a way to give the occupants the monetary benefit of their behavioral change. This could be applied to workers and other occupants of spaces that do not have any monetary interest in the use of the space. The only way to make the monetary compensation possible is to either make occupants pay for electricity or in a university setting this could be applied by making researchers pay for the use of equipment or spaces according to actual use.

Peoples' desire to maintain a positive self-concept may be an important driver for behavior. Hence what people consider as morally acceptable behavior is desirable. Therefore moral motives can be a good motivator for change. (Bolderdijk et al. 2013) A positive self image is related how the person views herself or himself. In a university and research setting it can be important for people to have a positive self-image when relating to other people. In order to be a successful researcher a person has to be valued by others and therefore it can be important to act in ways that promote a positive self-image both related to the person and the surroundings.

Often it is said that strong social norms are most influential on behavior. This concept of social norms means how people perceive that they are supposed to behave and what is socially acceptable behavior. Social norms can be changed and influenced by changing the behavior of larger groups and organizations. Social norms can be different in different settings meaning that there are socially acceptable ways to behave in different surroundings. (Chan et al. 2012; Arpan, Opel & Lu 2013). Hence applying the concept of social norms to energy consumption behavior social norms can be either useful or harmful. Social norms can be harmful if energy wasting behavior has become a social norm in an organization. In contrast social norms can be useful if energy efficient behavior is the norm. It may be difficult to influence social norms in the short term, but if influenced successfully they have a broad effect on behavior and can therefore make a large impact. It

can be useful to try to influence people that can change social norms by suitable intervention methods.

2.2.2 Energy Users

The underlying assumption in this study is that the effect of intervention methods on user behavior is contingent on the user's characteristics. In practice this would mean, that different intervention methods would need to be targeted at different user groups in order to reach maximum energy efficiency improvements. This would require that people could be divided into groups based on some factors yet to be determined. Therefore, the differences among energy users in general have to be examined. Presumably there are different types of energy users since there are different types of people in general. The variables that people can be divided into groups may of course differ in different settings and situations.

A study by Greene et al. (2014) found that there are two things in relation to energy reduction that the employees saw as most important: does the change hold a cost to the organization and does it hold a cost to the employee. The cost to the organization can have something to do with them having less of a competitive edge, e.g. holding a conference call instead of meeting with people face to face. To one person the cost is something that affects their lifestyle, e.g. it can require a certain level of effort in changing behavior. According to the study, there are in fact different types of personalities within the organizations. Furthermore, the same strategy to make an impact should be communicated differently to different types of employees. (Greene et al. 2014) However, in large organizations there may be large groups of different types of people and there the same methodology of dividing people into groups should be applicable within the organization. At a research organization this can be related to equipment used at research facilities. The researcher may think that they will not have the same resources as before, whereas from the organizational point of view there could be a decline in the quality of the research. Some people may think that these costs are acceptable while others think that sustainability should not be more important the costs (Greene et al. 2014).

Greene et al. (2014) found that organizations can be divided into different types of people based on who they believe should bear the cost of sustainability (Table 1). The interesting part of this study is related to the fact that different user-types can be identified and that they can be divided into groups. The groups then have two main characteristics attributed to them. This would suggest that it is possible to divide energy users into groups based on some variables, in the case of the aforementioned study, responsibility for the cost of sustainability.

Table 1 Overview of the four user types (Greene et al. 2014)

	Pragmatist	Libertarian	Housekeeper	Campaigner
Belief should bear the cost for sustainability	Neither company nor employee	Company	Employee	Both company and employee
Motivated by	Financial rewards, social norms, privileges and achievement	Financial rewards, privileges, status. Achievement and autonomy	Making a positive difference to the environment, shared goals, being part of a community	Personal values, concern for environmental issues and achievement
Types of initiatives they might consider	Quick wins, e.g. installing energy saving light bulbs	Company investment in more sustainable infrastructure	Employee behavior change	Initiatives that encourage employees to work with the company to create change

Pragmatists believe that there should be no added cost to sustainable activities. They think the action will then fail. Pragmatists are motivated by financial rewards, social norms and performance targets set by the company. Libertarians think that the employees should not have to be concerned about sustainability. Sustainability is the organizations responsibility. Libertarians are motivated by financial rewards, gaining privileges, status and being seen to be successful. They value a certain degree of freedom in their work. Housekeepers believe that it is the employees' responsibility that the organization is takes sustainability into account. In such an organization focus is on asking employees to act differently and use less energy. Knowing they are making a difference motivates them. For them being a part of a community is important. Campaigners thinks that sustainability is the responsibility of everyone, both employee and organization. They believe that sustainability should be embedded in everyone's roles, including the organization's role. Campaigners believe that everyone has to accept the cost of sustainability and investments should be made. Campaigners are genuinely worried for the environment and are motivated by personal values. They will want to ensure that the organization really is taking the environment and sustainability into account enough. The same message does not work for everyone. The messages should be clear, coherent and relevant. Differences in attitudes should be reflected in the communication strategy. (Greene et al. 2014)

A study by Franz-Balsen and Heinrichs (2007) about the different types of media that can be used for communicating messages about sustainability found there to be four different kind of media user types at the University of Lünenburg. The study included both students and staff of the university. A media mix is required to reach all user types. Communication management is also important.

The four user types found in the study are:

1. A campus life oriented user that reads all the papers distributed on campus
2. Local area oriented user that reads the local and city newspapers
3. A sociable person that is interested in events and social events
4. A curriculum-oriented person who regularly attends lectures and seminars, and visits the university web page frequently

Franz-Balsen and Heinrich's (2007) study also found that people can be categorized by how important they think sustainability is and how much it concerns them. Disciplinary cultures are highly relevant to a person's attitudes towards sustainability. The study found that members of the university campus were more knowledgeable about sustainability than the general population. Males belonging to technical faculties relied far more on technical solutions and did not believe their actions had a lot to do with sustainability.

A study by Rothe et al. (2012) found that age does make a difference in how people prefer to work. As the way people work also affects how much energy they use one could presume that age also has an effect on the way people use energy indirectly. Whether age should be considered when choosing an intervention method will be studied in the empirical part of this study.

According to Moser (2010) the following issues are important when trying to inform people of why they should change their behavior to more environmentally favorable behavior:

- What are the goals (scope and purpose) of the communication?
- Who is the audience (individuals, specific sub-populations, particular interest groups or socioeconomic sectors, etc.)?
- How is the issue framed? What language, metaphors, images, etc. are used?
- What messages, what information is conveyed and how can the content are made most useful and accessible? Content also relates to questions about the sources of information on climate change and their credibility [e.g., government, media, scientists—directly or scientific institutions, non-governmental organizations (environmental or other civic groups), or industry]?
- Who are the messengers (e.g., politicians, scientists, advocates, pundits, business people, celebrities, people of different ethnic or socioeconomic background and of different ages)?
- Through which channels and through which media and modes does the communication occur?
- How do we know the communication had the intended effect?

The media through which the message is promoted may have a positive or negative effect on the effectiveness of the message delivery. (Moser 2010) Therefore, it can be presumed that it is not only important to identify the most suitable intervention method, but also how the method is then put into practice. It is important to identify which form of media will be most effective in delivering the message after the intervention method has been identified. The preference of the occupants can be identified with a questionnaire simultaneously with identifying which intervention method may be the most effective.

Based on these findings, there are many possible variables that can be used to divide people into groups by. It has to be noted that there were not two studies that used exactly the same variables to categorize people. It can be assumed that the variables are specific to the study and settings. It would be interesting to know whether the variables would have been the same if the research methods had been identical. Not all of the studies specified what methods were used to identify the different groups and as such it is difficult to compare them.

2.2.3 Barriers to Behavioral Change

According to Maio et al. (2007) here are three factors that prohibit people from taking action even when they have intended to. These factors can be called barriers. Barriers prevent people from acting in a certain way, even if they had every intention to behave in a certain way. These barriers are often related to changing a familiar way of acting. The following may be reasons why people do not act in the way they intended to do:

1. Forgetting to act
2. Failing to seize the opportunity
3. Overcoming initial reluctance to act

People may become derailed from their intended action. This is an issue when the actions people take need to be repeated and happen over a long period of time. (Maio et al. 2007) Therefore measures to ensure that the intervention plan is followed should be taken. Reminders throughout the intervention are necessary. When deciding on an intervention method, these three factors should be considered. If prohibiting factors of the intervention are negated, the intervention should be more successful.

A study by Lorenzoni, Nicholson-Cole and Whitmarsh (2007) found that there are barriers related to the individual as well as barriers related to broader social level. It is important to know which barriers derive from society and which derive from the individual, as they cannot be eliminated in the same way. The social barriers sometimes translate into individual barriers since they are part of levels of society that should set an example to the individual. (Lorenzoni, Nicholson-Cole & Whitmarsh 2007)

The following barriers found in the study by Lorenzoni, Nocholson-Cole and Whitmarsh (2007):

Individual barriers:

- Lack of knowledge
- Uncertainty and skepticism
- Distrust in information sources
- Externalizing responsibility and blame
- Technology will save us
- Climate change is a distant threat
- Other things are more important
- Reluctance to change lifestyle
- Fatalism
- "Drop in the ocean" feeling

Social barriers:

- Lack of political action
- Lack of action by business and industry
- Worry about free-rider effect
- Social norms and expectations
- Lack of enabling initiatives

People may also have constraints that do not permit them to act differently. These can be, for example, financial. A person may simply not be able to buy a more expensive yet more energy efficient light bulb, even it would be cheaper in the long run. These constraints should be identified and, if possible, removed. An individual may want to change their behavior, but is unable due to these constraints. As such, constraints are a very difficult factor to remove as they are usually not voluntary. Constraints can be overcome by incentives. Incentives can be either monetary or non-monetary. (Stern 1999) The same phenomenon can be applicable at an organizational level. Organizations are often constrained by budgets and do not have unlimited monetary resources available. Hence, organizations may not be able to make all the investments that they otherwise would be willing to make. In an organization there may be a broader understanding for why certain investments would be appropriate but not have the monetary resources to make the initial investment.

A study by Chan et al. (2012) on community based social marketing found that it is important identify barriers so that they can be overcome. The study also described that it was crucial to succeed in eliminating the barriers, without incentives, for the intervention in the study to work. People do not feel ownership over the spaces as they are not their own, they do not get any incentives and user turnover is frequent, which limits the possible methods that can be used to change behavior. It also requires the interventions to be more powerful as they may have some constraints.

2.2.4 Methods for Behavioral Change

Tailored interventions are planned with the user in mind and planned according to their attitudes, beliefs and motivations (Maio et al. 2007). To know whether an intervention has been successful there has to be a before and after comparison. The reasons for which different types of interventions have been successful, has not been studied. (Abrahamse et al. 2005) In order to know what works in the future, it would be essential to know what factors really have made an impact. Interventions should not only be studied with one discipline in mind. They should take many different disciplines into account, and also consider their interactions of different disciplines with each other (Abrahamse et al. 2005). There is an apparent gap in the research field related to energy efficiency intervention and their success. It would be useful to know what intervention methods work and why in order to take advantage of this knowledge in the future.

The first step when planning to introduce an intervention to a university campus is to understand the complexity of the specific campus. This can be done by surveys to map the interests, attitudes and knowledge of the audience. Additionally, a media reception analysis could be conducted. (Franz-Balsen & Heinrichs 2007) This provides useful information regarding which media outlet would be most effective and reach the largest number of end-users in a specific target group.

It is clear that a profound understanding of the initial situation is the base for a successful intervention. There has to be knowledge about attitudes as they influence the way people see sustainable practices. Also, it is important to understand which intervention method to use. The intervention is in large related to what motivates different user types. The type of media a certain user type responds to be also different, some may respond better to information communicated through social media whilst others may be more responsive to face-to-face communication. And lastly, it is important to know how to communicate it to the different user types. Some may want simple facts, whereas others may require that the information be communicated in a fun way. The study by Franz-Balsen and Heinrichs (2007) found that the most important channel to communicate sustainability issues through is face-to-face, with the internet ranking as the second most important channel.

Communication has it limits. It is a good starting point for a structural change that enables more sustainable, and energy efficient, behavior in the organization as a whole. These changes can be gradual and ‘natural or imposed by the leaders. (Franz-Balsen & Heinrichs 2007) In the latter case, effective communication is necessary. Using the results from surveys and other information may aid in finding the most effective way to communicate the benefits of the changes to the users. Hence, it is important to understand the different users that the change concerns.

There needs to be effective ways of delivering messages, especially for the unmotivated and uninterested. Descriptive norms work well on some people, e.g. most people recycle and so should you. Descriptive norms are a way of stating that others do certain things and therefore you should too. This, for example, increased towel reuse at a hotel. Descriptive norms may also have adverse effects; they can for example increase consumption. Making problems moral issues instead of descriptive norms seem to be more effective in changing peoples’ behaviors. (Arpan et al. 2013)

It also has to be noted that two interventions rarely are identical even if they are based on the same intervention method. The intervention does always have to be tailored to the specific audience with the goal of the intervention in mind. Sometimes it may be useful to combine intervention methods in order to reach the best results possible. Additionally, there is not enough knowledge regarding why intervention methods have been successful in certain settings, which is why further knowledge regarding this would be useful to obtain in the future. Thus, further study into the field of energy efficiency interventions should be conducted.

Information and Education

Information and education is simply informing people of how things can be done and why they should be done in a certain way. How and when the information is delivered may be adjusted according to the situation and target of the intervention. The form of information and education should also be adjusted according to the audience. The same information cannot be delivered to children as to adults, for example.

Stern (1999) states that presenting information on its own is not always successful. This is also supported by McKenzie-Mohr (2000). However, it the information is well presented and aimed correctly changes in behavior can be obtained. Successful information campaigns have reduced certain environmentally non-desirable behaviors by 10-20 %. In the context of this study, the reduction of a certain behavior will not translate directly into a reduction in energy consumption. The reduction in energy consumption will be different depending on the setting and initial energy consumption of the building.

An increase in information will motivate households to save energy and so costs. The information works as a motivator. Households are motivated when they are shown how their actions for energy conservation reduce energy consumption. (Henryson et al. 2000) The same does not always apply in organizations and, in relevance to this study, universities. Occupants at the university are not directly affected by the costs of energy. They may, however, be interested in knowing how much resources are used on energy that could be used for something else instead. This is a question of how to present the information so that is as effective as possible for the target audience.

Feedback and Comparative Feedback

Feedback means that energy consumption is reported to the consumers. It can be done at different levels, e.g. households or organizations, or groups within an organization. The basis for this intervention method is measuring the energy consumption and in some cases knowing specifically what consumes the energy. Comparative feedback is simply an extension of feedback. It can comprise either comparing two time periods for the same consumption item or comparing two different consumption items to each other. By comparing consumption it is easier to know whether the consumption is increasing or decreasing and thereafter the reasons for the change can perhaps be identified and addressed. (Siero et al. 1996)

A comparative feedback study by Siero et al. (1996) was conducted, where one company received information about their energy consumption and how to reduce the consumption. Another company received the same information as well as the first company's energy consumption information. By making a group aware of another group that they can

compare themselves to and compete with makes the group more salient in achieving better results. An organization can set a common goal. (Siero et al. 1996)

The study conducted by Siero et al. (1996) shows that there were no significant changes in attitudes even though the energy wasting behaviors were reduced. Thus it can be concluded that even if the attitudes of people cannot be affected, their behavior can be changed. This can be useful when dealing with people whose attitudes are difficult or impossible to change.

Community Based Social Marketing

Social marketing is based on combining marketing and psychology. Marketing can be used to segment the targets of the intervention. Based on this a targeted message can be delivered to the focus group. Community based social marketing means that the community is activated in an effort to reduce energy consumption. (Chan et al. 2012) This can be done by for example organizing competitions with targeted purposes. Community based social marketing focuses on identifying barriers to behavioral change and eliminating them using psychological marketing strategies. (Chan et al. 2012; McKenzie-Mohr 2000)

Combining psychology and marketing was found to be effective in a study by Chan et al. (2012). Using more psychological tools when implementing intervention methods has been found to be more effective than neglecting psychological reasons for people's behavior (McKenzie-Mohr 2000). The study also found that it is important to deliver the message in a credible yet accessible manner. There are different manners that work for different people. People have different standards for what constitutes a credible source and have different preferences when it comes to communication of information. The main focus in community based social marketing is in eliminating identified barriers. As in any marketing campaign, the demographic and context in which the campaign is intended for should be well understood.

Incentives

Incentives include rewarding the targets of an intervention in some way. The incentive can be either monetary or non-monetary. According to Stern (1999) both monetary and non-monetary incentives can be useful as intervention methods. Often it is not the size of the incentive that matters, but the information that accompanies it.

Incentives can be effective in minimizing barriers for energy efficient behavior. However, the possibility of the behavior to resume when the incentive is discontinued has to be taken into account. (Chan et al. 2012) Therefore, it seems that it is important to promote changes in norms and it is important to consider ways to change behavior that have long lasting effects. An incentive may be useful when, as an example, considering researches that use the spaces for a limited time and thus their effect on the energy efficiency is also limited to that same timeframe. Thus the effect of the incentive may perhaps be least effective in the long run on the personnel that occupies the spaces for an indefinite times pan. It could be quite interesting if the researches took a survey before they began work in the spaces and based on that a tailored energy efficiency plan was made.

Combining Intervention Methods

A study by Abrahamse et al. (2007) found that mixing methodologies was more effective when conducting an intervention. They also found that using knowledge from many different fields was useful. Stern (1999) also proposes that mixing intervention methods will give the most favorable outcome.

By combining intervention methods a broader audience can be targeted, as the combination is more likely to be reach more people and be suited for a broader audience. However, there may be a chance that the interventions are not as effective as they do not focus on a specific target group and therefore may essentially be less effective and not reach the best possible result. Both possibilities have to be considered when designing and planning interventions. A choice between reaching as many people as possible or getting a better result from in a smaller group of people has to be made. These choices have to be weighed against each other. It could be useful to evaluate which is the intended outcome of the intervention: raising awareness or actually reducing energy consumption or eliminating energy wasting behavior of the target group.

Interventions were successfully combined and implemented in a study conducted by Petersen et al. (2007). The intervention methods used were incentives and feedback. The average reduction in electricity consumption during the study was 32%, with one research subject reducing electricity consumption with as much as 56%. The intervention was organized as competition between university dorms and the winner received a substantial reward that could be spent on the dorms. It seems that the notion of organizing competitions and receiving a reward would be very efficient in the setting of this specific study. It would be interesting to see if the same applied for a different type of end-user ot in a different setting.

Energy Reduction of Interventions

There are many studies about different intervention methods. A sample of results from various interventions is presented in Table 2. The reduction in energy consumption varies between 0% and 16%. The results also include reduced energy wasting behavior. It is clear that there are differences in results regarding the energy savings or reduction in energy wasting behavior. It should also be stated that there is no good way in which to compare these results as the interventions are performed under different sets of circumstances and are in no way connected to each other.

Some of the results only include results from the intervention period, which means that the long-term effects may not have been as good as the results obtained. The study by Senbel, Ngo and Blair (2014) includes post intervention results and demonstrates that long-term behavioral change is possible. The best possible outcome of an intervention would clearly be that there would be long-term decreases in energy consumption or energy wasting behavior, as this would maximize the advantages of a single intervention. As such it would be beneficial to ensure that the outcome of the intervention is as favorable as possible.

Table 2 A review of results of energy conservation interventions

Method	Results	Target	Source
Comparative feedback	Greater reduction in energy wasting behavior compared to only receiving information about energy consumption	Organizations	(Siero et al. 1996)
Community based social marketing	Improved energy consumption behavior	University Campus	(Chan et al. 2012)
Education	14.08 % reduction in energy consumption	Households	(Ouyang & Hokao 2009)
Education and information	0-10 % reduction in energy consumption	Households	(Henryson et al. 2000)
Education and information	No statistically significant changes	University dorms	(Marcell, Agyeman & Rappaport 2004)
Education and information based on social-psychological model	Approximately 10 % after weather correction	US Military Households	(McMakin 2002)
Personalized information	8.7 %	Households	(Benders et al. 2006)
Social media marketing	16 % reduction during the program	University dorms	(Senbel, Ngo & Blair 2014)
Tailored information	5 %	Households	(Abrahamse et al. 2007)
Incentives and feedback	32% (only electricity)	University dorms	(Petersen et al. 2007)

The studies do not include comparisons between different user groups and focus on only one specific type of energy users. The studies often have limited focus groups and there have not been any comparisons of how effective to similar intervention methods have been when using them on different user groups. As such, no conclusions regarding results of targeted intervention methods have been found. It can be stated that no theoretical base for how different intervention methods will influence different user types can be made. Also, there is no way in comparing the energy usage as some of the studies included all energy and some neglected for example heating. Not all studies specified what energy forms were included.

2.3 Theoretical Framework

The theoretical framework is the final result of the literature review. It is what the empiric study will be based upon. The theoretical framework of this thesis is as shown in. The factors included in behavioral patterns, barriers and end-users' motivations constitute the base for choosing an intervention method. These three should be mapped out before choosing an intervention method and they constitute context of the TF. The purpose of an intervention is, essentially, to change behavior through motivating and/or eliminating barriers.

2.3.1 Model of Energy Consumption Behavior at university campuses

There are a number of intervention methods to choose from. These should be chosen based on the initial findings about the end-users. There are many factors related to the intervention method that should be mapped out at this stage, e.g. what type of media to use when communicating with the end-user and how to frame the message.

In some situations it may be enough to get the end-user to acknowledge that they should or could behave differently. The acknowledgement in itself may be enough to make some end-users change their behavior. In some cases the intervention should be aimed at both making end-users acknowledge that the behavior should be changed as well as facilitating the change in behavior. The outcome should be an increase in energy efficiency by an increase in operational energy efficiency.

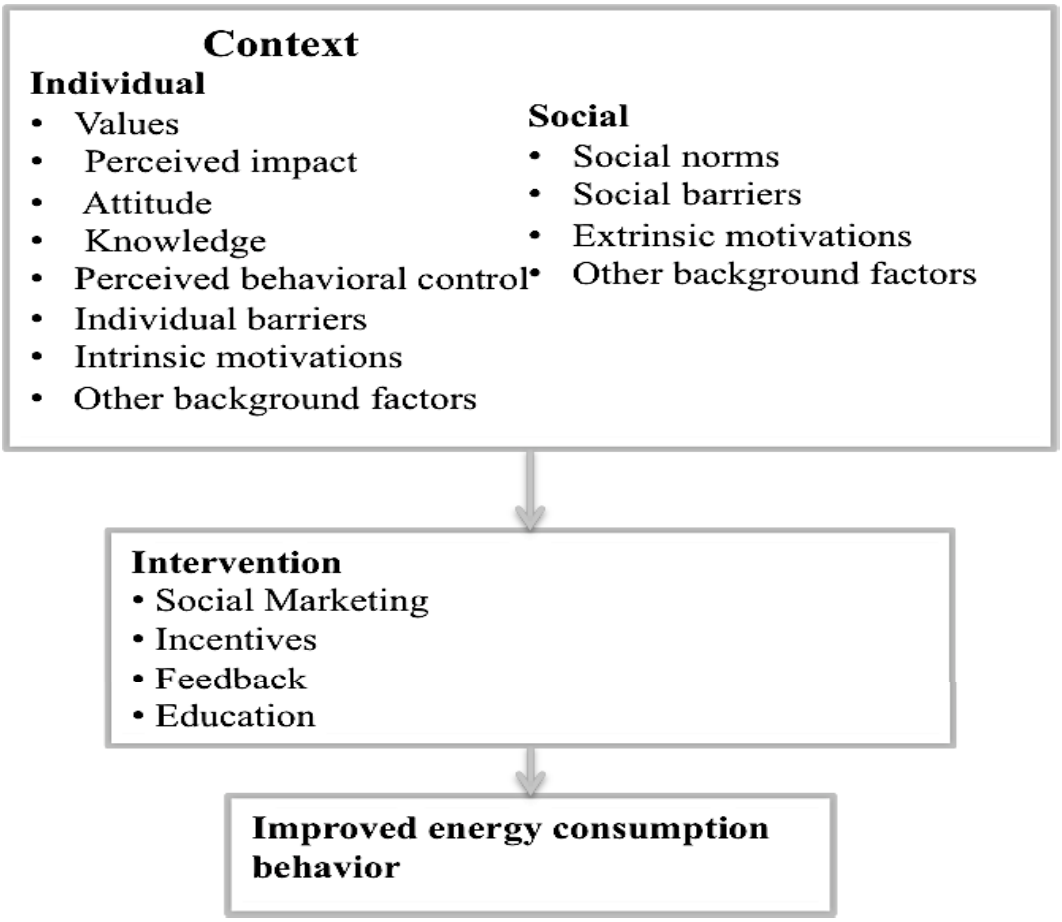

Figure 8 Theoretical framework

The theoretical framework (TF) was used as the basis for creating the questionnaire. The questionnaire included questions related to all aspects of the TF. The TF helped to determine the possible underlying constructs for which intervention method is most suitable for the different user groups that are discovered during the study. The TF consists of three parts: the context in which the intervention will take place, the intervention methods and the desired outcome of intervention methods. The focus of the empirical research is on the connection between the context and the intervention methods. The

connection between the intervention methods and the outcome was focused on in the literature review.

2.3.2 Propositions

Based on the literature review some connections between interventions and variables can be made. These relate back to the research questions posed in this study. The connections will then be tested in the empirical part of this thesis. The propositions are as follows:

RQ2: What similarities or differences can be found between different users at a university campus?

Some differences regarding the different variables will be found. The general background factors will be different for different end-users. Also, there will be some differences regarding motivations and barriers of the research subjects. This is based on for example the research conducted by Greene, Crumbleholme & Myerson (2014) where they found that people had different values and thus valued different ways of improving energy efficiency.

RQ3: What methods are most effective at influencing the energy consuming behavior of different users at university campuses?

Based on the literature review and the empirical setting of this research, it could be assumed that education as well as feedback would be good intervention methods at university campuses. Feedback and education would, based on the literature review, seem to fit people who want to gain more knowledge and need to know why it would be useful to reduce energy consumption.

3 Research Design

In this chapter the methods of this thesis are presented and justified.

3.1 Research Strategy

According to Burns and Bush (2006) the choice of the most appropriate research design depends on the objectives of the research. One of the aims of this research is to explore the possibilities to group users together based on certain factors and also gain an understanding of what could influence the choice of intervention method. Therefore an exploratory research was conducted. Exploratory research objectives are often used to clarify problems and to gain background information. In this study, exploratory research was used to examine the variables that affect the choice of energy efficiency intervention methods as indicated by the literature review. Some aspects of this study can also be viewed as confirmatory since the study also related to previous studies. It is confirmatory in the sense that the factors influencing have been found based on previous studies. However, the study of the relationships between the factors and the intervention method is exploratory and not based on previous theories.

3.2 Empirical Setting

The research is focused on the Viikinkaari area of the University of Helsinki's Viikki campus, and more specifically on the Biocentre buildings. The area of the buildings is presented in Table 3. The number of personnel in the buildings is approximately 1000 and the number of students is approximately 3000. These numbers are very dynamic and there is no centralized data available for the number of people that occupy the buildings as it changes constantly. The focus in this study is on those who work for the university. This means that most of the students are excluded, except doctorate students and those working for the university. There are many different types of spaces in the buildings. There for example are spaces for lectures, workspaces and research laboratories.

Table 3 Building areas of the Biocentres

	Area/ m^2	
Biocentre 1	16298.8	
Biocentre 2	15384.2	Total
Biocentre 3	15138.6	46821,6

The heating energy consumptions of the Biocentres are presented in Figure 9. The heating energy consumption is weather corrected. Since the data for the entire 2014 is not yet available, it has been excluded from the data. The combined heating consumption of the Biocentres is presented in Table 4.

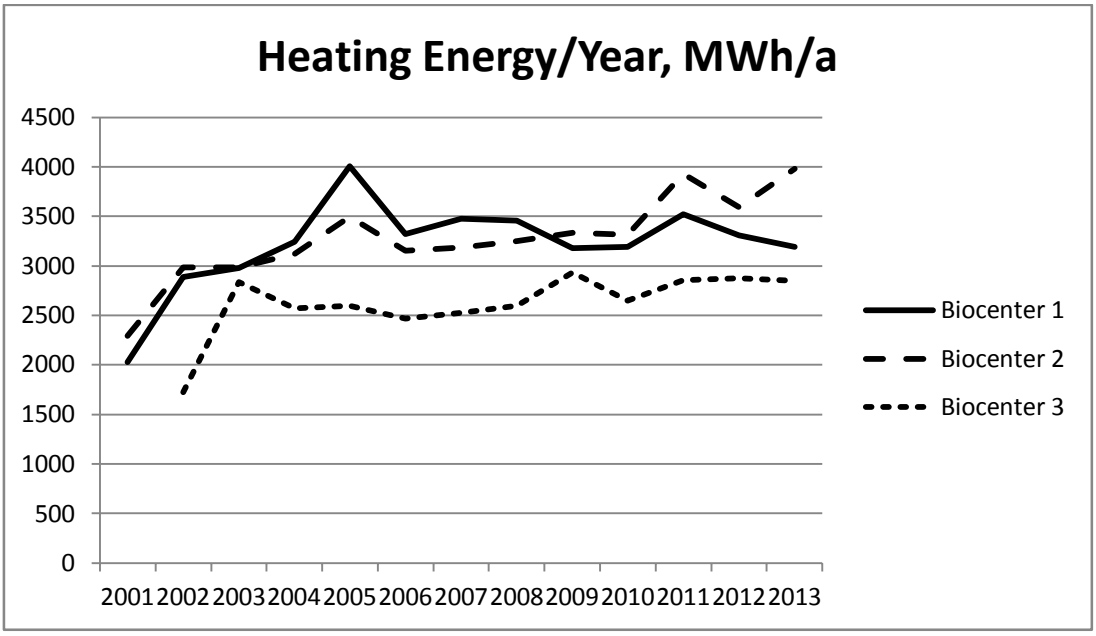

Figure 9 Energy consumed by space heating at the Univerisy of Helsinki

Table 4 Combined energy consumption for heating of spaces at the University of Helsinki

Year	Heating Energy, MWh	
2002	7596	
2003	8799	
2004	8932	
2005	10096	
2006	8945	
2007	9183	
2008	9302	
2009	9442	
2010	9158	
2011	10302	
2012	9772	Average:
2013	10022	9296

The operational energy consumptions of the Biocentres are presented in Figure 10. Since the data for the entire 2014 is not yet available, it has been excluded from the data. The combined operational energy consumption of the Biocentres is presented in Table 5. It should be noted that there was a renovation project in Biocenter 3 during 2011, which influences the operational energy consumption of the building. Additionally, it influences the total energy consumptions of the buildings and the average operational energy consumption of the buildings.

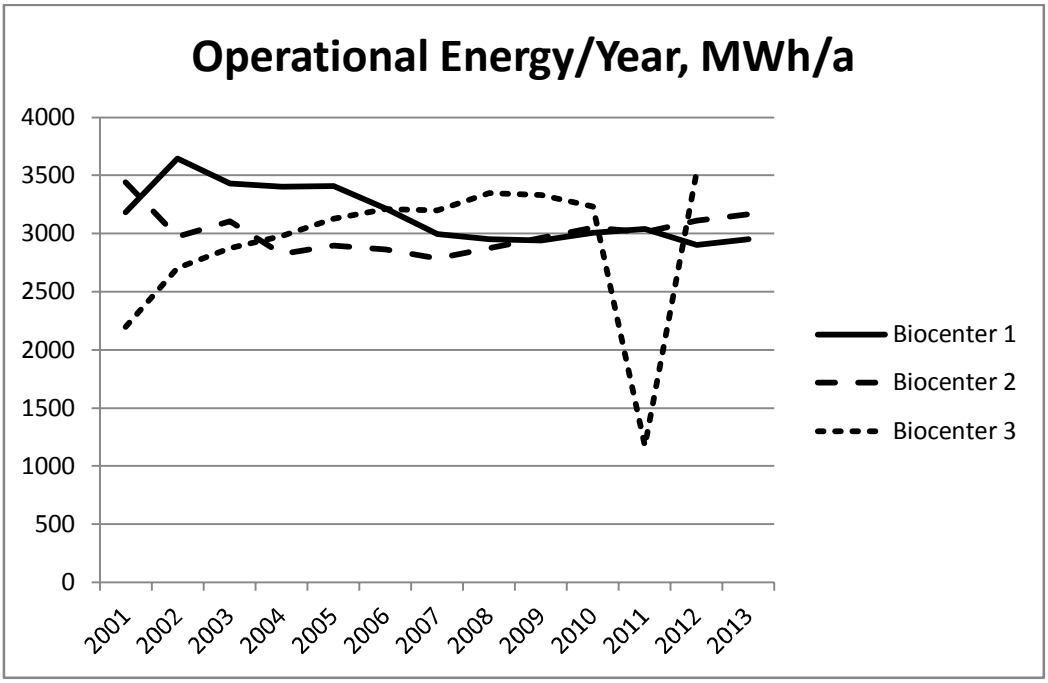

Figure 10 Operational energy consumed at the University of Helsinki

Table 5 Combined operational energy consumption at the University of Helsinki

Year	Electricity, MWh	
2002	8815	
2003	9240	
2004	9101	
2005	9279	
2006	9210	
2007	8996	
2008	9019	
2009	9249	
2010	9391	
2011	9283	
2012	7184	Average:
2013	9654	8989

The potential energy savings include only those that can be obtained by changing behavior. Those that could be obtained by improved technology are outside the scope of this study. However, it has become clear during the study that both by improving technology and building features, and changing behavior, reductions in energy consumption can be obtained.

There have not been previous studies that focus on comparing intervention methods in different settings and between different end-user types. Based on the theoretical study, better results should be obtained if using intervention methods that consider the users preferences and their backgrounds. When the psychological variables are considered in

choosing intervention methods they should be more efficient. The findings of this study do indicate that there is a link between psychological factors and intervention methods, as well as other factors, and can be used as the basis for further research into the subject.

Based on the literature review, reductions in energy consumption of 0% to 20% can be reached by changing user behavior. Therefore calculations based on this are performed. The calculations are of a basic level as no actual measurements of the effects the intervention methods have on total energy consumption have been made in this study. Calculations are made separately for heating and operational energy and also for the combined energy consumption. Savings ranging from 0 MWh to 3666 MWh could be obtainable. 0 MWh would require that there would be no savings, whereas 3666 MWh would require savings of 20% in both operational and heating energy. The actual savings of interventions is likely to be somewhere in between. These reductions corresponds to savings of 0 € to 256 620 € (Tilastokeskus 2014)

Table 6 Potential savings of intervention methods

Savings	Heating	Potential savings	Operational	Potential savings	Potential combined savings
0%	9295,80	0,00	9035,03	0,00	0,00
1%	9295,80	92,96	9035,03	90,35	183,31
2%	9295,80	185,92	9035,03	180,70	366,62
3%	9295,80	278,87	9035,03	271,05	549,92
4%	9295,80	371,83	9035,03	361,40	733,23
5%	9295,80	464,79	9035,03	451,75	916,54
6%	9295,80	557,75	9035,03	542,10	1099,85
7%	9295,80	650,71	9035,03	632,45	1283,16
8%	9295,80	743,66	9035,03	722,80	1466,47
9%	9295,80	836,62	9035,03	813,15	1649,77
10%	9295,80	929,58	9035,03	903,50	1833,08
11%	9295,80	1022,54	9035,03	993,85	2016,39
12%	9295,80	1115,50	9035,03	1084,20	2199,70
13%	9295,80	1208,45	9035,03	1174,55	2383,01
14%	9295,80	1301,41	9035,03	1264,90	2566,31
15%	9295,80	1394,37	9035,03	1355,25	2749,62
16%	9295,80	1487,33	9035,03	1445,60	2932,93
17%	9295,80	1580,29	9035,03	1535,95	3116,24
18%	9295,80	1673,24	9035,03	1626,30	3299,55
19%	9295,80	1766,20	9035,03	1716,65	3482,86
20%	9295,80	1859,16	9035,03	1807,01	3666,16

3.3 Data Collection

The questionnaire (Appendix 2) developed for this study is based on a questionnaire used by Ucci et al. (2014) who in their study aimed to develop a tool for measuring user-behaviour within the context of energy saving in factories and offices, with some modifications. The questionnaire in the original study consisted of three main sections:

general information, attitudes towards energy efficiency and self reported behavior and knowledge regarding procedures. For example, some questions were added from a study conducted by Pelletier et al. (1998) about motivations. Some questions had to be invented in order to cover all the variables discovered during the literature review. The questionnaire consisted of 40 Likert-scale questions with the range 1 to 6. Also, some multiple-choice questions related to the background of the respondents were included. There were some open-ended questions included for the respondents to give suggestions related to energy efficiency improvements and general feedback.

The questionnaire was pre-tested on a small group from a similar setting as the target group. Some small adjustments were made based on the testing of the questionnaire. The changes that were made are related to the instructions on how to fill out questions 8 and 12. Some small modifications were made to the wordings of the questions to make them more understandable.

Some of the questions were invented for the purpose of this study. When inventing new questions method biases are important to understand and minimize. Method biases are a source of concern when conducting research related to behavior. Method biases are the main reason for measurement errors in behavioral research. (Podsakoff et al. 2003) The focus of this study is on behavior and as such method biases have to be acknowledged. The aim when constructing the questionnaire was to minimize any method biases. Method biases can arise from having a common rater, a common measurement context, and a common item context or from other item characteristics. In many studies more than one of these method biases may be present, and often is. Hence, it is important to acknowledge them and try to take measures to minimize their effect.

All methods to reduce method biases presented by Podsakoff et al. (2003) cannot be taken into consideration for practical reasons in this study. For example, the large number of questionnaires distributed limits the ways in which the questionnaire can be distributed. Ensuring respondent anonymity may, however, increase the probability of respondents answering honestly and ensuring that they can express their true opinions. This is also important when ensuring that the research is conducted in an ethical manner. Additionally, the participation in the study was entirely voluntary to further ensure that the research was ethically conducted. (Varantola et al. 2012)

Additionally, counterbalancing question order may help minimize method biases in this questionnaire. In this study this means that questions closely related to each other are placed far from each other in the questionnaire. This can eliminate the respondents' tendency to answer the questions logically and coherently. Also, the questions have been constructed as simple statements in order to reduce their ambiguity and ensuring that respondents cannot misunderstand the question. Double-barreled questions have been avoided throughout the questionnaire for the same reasons. (Podsakoff et al. 2003)

A link to the Internet questionnaire was distributed to the intended participants of the questionnaire via e-mail twice. A link to the questionnaire was also posted to the University of Helsinki's internal Web site. The intention was to reach as many occupants of the Biocentres. The approximate amount of occupants at the Biocentres is 1000 and the questionnaire yielded 196 answers, which corresponds to a response rate of approximately 20%.

The variables were coded for the analysis of the questionnaire. The codes are presented in Table 7. The internal consistency of the variables was analyzed by testing their Cronbach's Alpha. The alpha values were not excellent and some items were eliminated based on the test in order to improve internal consistency of the variables. Based on the inexperience of the researcher, alpha values smaller then 0.5 resulted in using fewer or only one item. Alphas of smaller value than 0.5 are generally considered unacceptable and higher values are more desirable. There is no lower limit for alpha values and the maximum value of Cronbach's alpha is 1. (Santos 1999)

Table 7 Variable codes

Variable	Code
Feedback	FEEDB
Community based social marketing	SOCMAR
Incentives	INCENTIVE
Education	EDUC
Role at University	ROLE
Does respondent have an own permanent workstation at the university	PERMANENT
Is respondent in a leadership position	LEADER
Gender of respondent	GENDER
Faculty to which respondent belongs to	FACULT
Building in which respondent spends the most time	BUILD
Amount of time respondent spends on campus on average, h/week	TIME
Age of respondent	AGE
Perceived behavioral control	CONTR
Individual barriers	INDBARR
Attitudes	ATTIT
Values	VALUE
Intrinsic motivations	INTMOT
Extrinsic motivations	EXTMOT
Social barriers	SOCBARR
Social norms	SNORMS
Knowledge	KNOWL
Respondents possibilities to affect energy consumption	POSS
Self reported behavior	BEHAV

There were 196 respondents to the questionnaire. Not all the respondents answered to all the questions. The number of respondents that were included in the different analysis methods is indicated in each section of the results. 62.2% of the respondents were female and 37.8% male. (Table 8) All respondents are part of the Viikki campus and most were occupants of the Biocentres. They belonged to the different faculties as indicated in Table 9. Table 10 indicates the building in which the respondents spend most of their working time in. Additional background information of the respondents is presented in tables 7-9. According to the University of Helsinki, the respondents represent the overall occupants at the Viikki campus quite well.

Table 8 Gender of respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Female	122	62,2	62,2	62,2
	Male	74	37,8	37,8	100,0
	Total	196	100,0	100,0	

Table 9 Faculty of respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Faculty of Agriculture and Forestry	23	11,7	11,8	11,8
	Faculty of Biological and Environmental Sciences	80	40,8	41,0	52,8
	Faculty of Pharmacy	34	17,3	17,4	70,3
	Institute of Biotechnology	56	28,6	28,7	99,0
	Other (please specify)	2	1,0	1,0	100,0
	Total	195	99,5	100,0	
Missing	6	1	,5		
Total		196	100,0		

Table 10 Building in which respondent spends most time

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Biocentre 1	75	38,3	38,3	38,3
	Biocentre 2	39	19,9	19,9	58,2
	Biocentre 3	56	28,6	28,6	86,7
	Other (please specify)	26	13,3	13,3	100,0
	Total	196	100,0	100,0	

Table 11 Respondent's role at the university

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Administrative personnel	13	6,6	6,6	6,6
	Bachelor's student	8	4,1	4,1	10,7
	Doctorate student	49	25,0	25,0	35,7
	Facility and service personnel	4	2,0	2,0	37,8
	IT staff	2	1,0	1,0	38,8
	Master's student	12	6,1	6,1	44,9
	Other personnel	6	3,1	3,1	48,0
	Support personnel for teaching and research	15	7,7	7,7	55,6
	Teaching and research staff	85	43,4	43,4	99,0
	Teaching personnel at the training school	2	1,0	1,0	100,0
	Total	196	100,0	100,0	

Table 12 Respondent has a permanent working station at the university

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	29	14,8	14,8	14,8
	Yes	167	85,2	85,2	100,0
	Total	196	100,0	100,0	

Table 13 Respondent is in a leadership position at the university

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	157	80,1	81,3	81,3
	Yes	36	18,4	18,7	100,0
	Total	193	98,5	100,0	
Missing	3	3	1,5		
Total		196	100,0		

3.4 Data Analysis

The statistical analysis was done in several stages. At first the different variables are examined by exploring their correlations to each other. Both correlations between intervention methods and dependent variables are explored. Additionally, the relationship between different independent variables will be examined. In this phase of the analysis all variables will be included, as only the ordinal variables can be included in the factor and regression analysis. The IBM SPSS software was used to conduct the statistical analysis.

3.4.1 Factor Analysis

Factor analysis was used in order to develop an understanding of the underlying features to what intervention methods would be most suited for building end-users at university campuses, and to reduce the number of variables. Factor analysis is a method often used when the latent structure of variables needs to be defined. Factor analysis can be used to reduce the number of variables in the analysis by grouping correlated variables into smaller sets of variables. These variable sets are known as factors and they are assumed to represent the dimensions of the data and represent latent variables. This was done in order to understand what factors would be helpful in grouping together users when trying to form user types.

3.4.2 Multivariate Regression Analysis

Finally, both the initial variables and the results from the factor analysis will be used to conduct regression analyses to determine to what extent the different variables are related to the intervention methods. The construct of these regression models will also be examined in order to determine to what extent the factors and variables influence the choice of intervention method.

The aim of the regression analysis is to find the constructs in the study that affect the suitability of different intervention methods for different types of people. Examining how well the examined variables explained the suitability of the intervention methods does this. In general, the regression models only explained some of the suitability. It has to be noted that behavior is difficult to predict and there may be many variables influencing the choices of the respondents that have not been included in this study.

When considering the regression models, both their constructs and their level of explaining the phenomenon were examined. The explanation level was determined by looking at the R^2 value of the models. The constructs were examined by looking at the significance level of the variables for the model. Additionally, the β of the variables was examined to determine how the variables affect the phenomenon and to what extent compared to the other variables.

The regression analyses based on the factor scores are examined in a similar way. The analysis is somewhat different as factor scores are latent variables and have to be used with caution. Factor scores are aggregated variables that provide information about person's placement on the factor or factors. It has to be taken into consideration that the factor scores are sensitive to the extraction and rotation methods. Therefore they may be different if different methods of factor analysis were to be used. It has to be noted that the further analysis can be different if the factor scores would be computed using other methods. (DiStefano, Zhu & Mindrila 2009)

4 Results

In this chapter the results of the questionnaire will be presented and analyzed.

4.1 Descriptive Statistics

The descriptive statistics of the questionnaire are presented in Table 14. The descriptive statistics indicate that there is a large difference in how much people spend time in the university's spaces. This also means that some people have a larger influence on the energy efficiency at the university than others. People of all ages are present at the university, which means that there are people from many generations working there. This could indicate that there is a difference in how these people work as Rothe et al. (2012) stated in their research.

In general, the descriptive statistics indicate that the people working at the Viikki campus think that energy efficiency and energy consumption reduction is important. Hence, it can be deduced that influencing the behavior of the respondents should be easy. Furthermore, their self-reported energy consumption behavior seems to indicate that they already perceive that they act in efficiently. This could indicate that the respondents do not think that they need to change their behavior. However, there is no indication that there is no room for improvement in energy consumption behavior.

Based on the means, community based social marketing would seem to be the most suitable intervention method with a mean value of 4.52 and standard deviation of 1.127. Incentives seem to be the least suitable with a mean of 2.59 and a standard deviation of 1.280. Based on the entire questionnaire and the initial analysis, community based social marketing would be most suitable if choosing an intervention method for all the occupants.

Table 14 Descriptive statistics

	N	Minimum	Maximum	Mean	Std. Deviation
TIME	196	6	65	37,38	10,361
AGE	196	21	65	38,17	11,156
FEEDB	177	1	6	3,42	1,487
INCENTIVE	160	1	6	2,59	1,280
SOCMAR	160	1	6	4,52	1,127
CONTR	161	1	6	3,95	1,317
INDBARR	160	1,00	6,00	3,3969	,99858
ATTIT	180	1,00	6,00	5,0333	1,13551
VALUE	180	1,00	6,00	5,2750	1,08863
BEHAV	162	1,00	6,00	4,6588	1,05847
EDUC	178	1,00	6,00	3,2978	1,31639
INTMOT	161	1,00	6,00	4,3975	1,27857
EXTMOT	160	1,00	6,00	2,2219	,88443
SOCBARR	178	1,00	6,00	2,9944	1,03742
SNORMS	178	1,00	6,00	3,0815	1,10102
KNOWL	180	1,00	6,00	2,9380	1,16194
POSS	180	1,50	6,00	4,1505	,86719
Valid N (listwise)	159				

4.2 Correlation Analysis of the Questionnaire

Examining the correlations between respondents' answers for different variables indicates the relationship between these variables. There are some general relationships that are detectable in the correlation table. (Table 15) This way the variables can be explored and some initial indications of what variables influence the suitability of a specific intervention methods may emerge.

There is a very strong correlation between the respondents valuing energy efficiency and their positive attitude towards energy efficiency ($r= 0.817$, significant at $p<0.01$). There is a strong correlation between respondents perceived ability to influence energy efficiency and people valuing energy efficiency ($r= 0.493$, significant at $p<0.01$) as well as those who have positive attitudes towards energy efficiency ($r= 0.567$, significant at $p<0.01$). There are also strong correlations between intrinsic motivations and valuing energy efficiency highly ($r= 0.656$, significant at $p<0.01$) as well as positive attitudes towards energy efficiency ($r= 0.598$, significant at $p<0.01$). The respondents' role at the university and the respondent age of the respondent correlate strongly ($r=0.457$, significant at $p<0.01$). There also seems to be a strong relationship between valuing energy efficiency as important and being motivated by intrinsic motivators. There is also a correlation between respondents who value energy efficiency, as well as those who have positive attitudes energy efficiency, and good self reported behavior in regards to energy.

It seems interesting that social norms and intrinsic motivations are positively correlated ($r=0.297$, significant at $p<0.01$). It could suggest the respondents consider social acceptance to be intrinsically satisfying. Usually intrinsic motivations refer to internal motivations such as feeling good when doing something good. Another interesting finding seems to be that the more time a respondent spend time at the university, the less lower their attitude towards energy efficiency seems to be ($r=-0.166$, significant at $p<0.05$). This could be because the more time is spent on research or working, the less significant the energy efficiency of the buildings seem. In reality, the more time a person spends in a building, the more they can influence its energy efficiency.

4.2.1 Correlations between Feedback and Other Variables

It seems interesting that those who already think that they know about energy efficiency do not value feedback as highly indicated by the variables being negatively correlated ($r=-0.260$, significant at $p<0.01$). It also seems that those who do not have a permanent workstation at the university are less likely to want feedback about their energy consumption, which would seem quite logical as there may not be a clear pattern to how and where they work ($r=-0.164$, significant at $p<0.05$).

4.2.2 Correlations between Incentives and Other Variables

A strong correlation is detectable between external motivations and incentives. This would indicate that persons that view outside motivators as important also consider it important to be rewarded for ones efforts ($r=0.259$, significant at $p<0.05$). There is quite a clear connection between these two variables since they are both related to factors external to the respondent. It is quite surprising that there were no correlations between wanting to be rewarded for reducing energy consumption and any other variable.

4.2.3 Correlations between Education and Other Variables

There is a clear positive correlation between those who wish to obtain more information about energy efficiency and those who perceive that they already have some knowledge in the area ($r=0.665$, significant at $p<0.01$). It has to be highlighted that the questionnaire does not test actual knowledge, but measures perceived knowledge related to energy consumption at University of Helsinki.

A correlation between the respondents' age and their interest in learning new information are correlated. ($r=0.217$, significant at $p<0.01$). This means that the older the respondent is, the more eager they are to receive new information about energy efficiency. This seems a bit counterintuitive, as generally younger persons are considered more eager to learn things. This may also be a result of the setting in which the study is conducted. The older respondents are perhaps seasoned researchers that always wish to acquire more knowledge. The other possibility is that young people feel that they already know enough and they do not perhaps think that knew knowledge would help them in reducing energy consumption.

4.2.4 Correlations between Community Based Social Marketing and Other Variables

There is a positive correlation between positive attitudes towards energy efficiency and saving energy as part of a group ($r=0.406$, significant at $p<0.01$), which would suggest that community based social marketing would be a suitable intervention method. There is also a correlation between the community based social marketing variable and the respondents' perceived possibilities to influence energy efficiency ($r=0.424$, significant at $p<0.01$) as well as the respondents'' perceived ability to change their own behavior ($r=0.365$, significant at $p<0.01$).

Table 15 Correlation table

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1. FEEDB	1																						
2. SOCMAR	,258**	1																					
3. INCENTIVE	,218**	,031	1																				
4. EDUC	-,233**	-,004	,013	1																			
5. ROLE	,006	-,046	-,038	,065	1																		
6. PERMANENT	-,164*	-,012	,040	,079	,189*	1																	
7. LEADER	,097	,022	-,019	,116	,377**	,160*	1																
8. GENDER	,043	-,056	,018	,096	,120	-,081	,182*	1															
9. FACULT	,062	-,107	,021	-,021	,124	,089	-,044	,007	1														
10. BUILD	,014	,042	-,016	,093	-,073	,009	-,031	,171*	-,062	1													
11. TIME	-,062	-,038	-,041	-,040	,116	,099	,311**	,033	,032	-,142	1												
12. AGE	-,102	-,121	,054	,217**	,457**	,286**	,408**	,183*	,087	,004	,122	1											
13. CONTR	,109	,365**	-,052	,108	-,067	-,129	,005	-,068	-,176*	,005	,023	-,020	1										
14. INDBARR	-,037	-,191*	,083	,223**	,077	,020	,071	,221**	,255**	,001	,105	,032	-,108	1									
15. ATTIT	,362**	,406**	-,077	-,086	,059	-,032	-,020	-,051	-,098	,153	-,159*	-,138	,325**	-,101	1								
16. VALUE	,287**	,433**	-,066	-,041	,000	-,015	,008	-,117	-,166*	,170*	-,149	-,069	,383**	-,158*	,817**	1							
17. INTMOT	,229**	,387**	-,040	,006	,052	-,050	-,016	-,157	-,089	,003	-,045	,036	,419**	-,002	,598**	,656**	1						
18. EXTMOT	,139	-,157	,259**	,129	,028	-,100	-,055	,049	-,116	,010	-,073	-,032	-,137	-,005	-,121	-,135	-,074	1					
19. SOCBARR	-,208**	-,240**	,033	,359**	-,022	,049	-,060	,068	,114	-,017	-,009	,000	-,067	,272**	-,415**	-,410**	-,322**	,280**	1				
20. SNORMS	,118	,264**	,071	,269**	-,169*	-,137	-,079	-,038	-,178*	,122	-,025	,000	,392**	-,029	,233**	,256**	,397**	,176*	-,039	1			
21. KNOWL	-,260**	-,075	-,027	,665**	,070	,032	,055	,133	,048	,106	-,072	,262**	,115	,332**	-,086	-,123	,033	,135	,393**	,348**	1		
22. POSS	,338**	,424**	-,067	-,092	,014	-,050	,111	-,033	,047	-,005	-,021	,009	,419**	-,052	,567**	,493**	,398**	-,059	-,146	,315**	,005	1	
23. BEHAV	,101	,281**	-,125	,201*	,024	,114	,041	,026	-,144	,139	-,028	,039	,328**	-,066	,332**	,383**	,383**	-,071	-,097	,314**	,154	,272**	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

c. Listwise N=156

4.3 Factor Analysis of the Questionnaire

The Maximum Likelihood extraction method was used as suggested by Costello and Osborne (2005). Costello and Osborne (2005) also suggest that the Varimax rotation method is the most commonly used method and is also used in this study as it presents easily interpretable results. Pre-analysis tests for the suitability of the data for factor analysis were explored. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.771, and the Bartlett test of sphericity was significant at $p<0.001$, indicating the that the data is suitable for factor analysis. The factor analysis was performed as an exploratory factor analysis. Confirmatory factor analysis was used to determine whether the initial result was the best fit or not for the sample. Based on the testing, the initial solution was the solution that fit the sample best. (Table 16) The two factors were selected as independent variables for the multiple regression models (Tabachnick & Fidell cop. 2001; Johnson & Wichern 2002).

External motivations were excluded from the two-factor model, as this variable did not load strongly on any factor. The elimination was also done based on inspection of the anti-image table. The anti-image correlation value for external motivations was such that the variable could be excluded from the two-factor model. Two selected factors explained 51.5 % of the total variance.

Table 16 Testing of the factor analysis

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,771
Bartlett's Test of Sphericity	Approx. Chi-Square	515,311
	df	28
	Sig.	,000

The results of the factor analysis yielded in a two-factor model for this data. Factor one had high loadings for the following variables: values, attitude intrinsic motivations, perceived possibilities to affect energy consumption, perceived behavioral control and negatively onto social barriers. This factor includes variables that demonstrate internal attributes of a person's relation to energy efficiency.

Factor 2 had high loadings for knowledge and social norms. These can be viewed as factors related to how a person perceives the surroundings. Knowledge relates to how much the person knows about the energy efficiency at the university and what is done to improve it. Social norms relate to how much a person thinks socially acceptable behavior influences their own behavior.

Table 17 Rotated factor matrix and factor score coefficients

	Factor loadings		Factor score coefficients	
	Factor		Factor	
	1	2	1	2
VALUE	,908		,437	-,157
ATTIT	,887		,349	-,126
INTMOT	,725		,133	,142
POSS	,599		,079	,103
CONTR	,459		,055	,193
SOCBARR	-,448		-,057	,192
KNOWL		,633	-,017	,370
SNORMS		,583	,046	,367

The factor scores obtained in the factor analysis were saved (Table 17) and used in the regression analysis. The factor scores indicate how a person's answer load on the factors compared to the other respondents. A high factor score indicates that the person's answers in general are above the mean of the questions. Factor scores are useful as they also consider how the specific variable is loaded onto the factors. Therefore they can be used to determine how the factors are related to the intervention methods.

4.4 Regression Models with Intervention Methods as Dependent Variables

The purpose of the regression models is to find out what variables influence the apparent fit of an intervention method for a specifict end-user type based on both factor scores and initial variables. The importance of the variables in this will be determined by identifying the constructs of the models using intervention methods as dependent variables.

4.4.1 Feedback Regression Models

Based on the multiple linear regression analysis, factor one could be helpful in predicting the suitability of feedback (β=0,528, p>0.001) as an intervention method at the University of Helsinki. The R^2 value is, however, very low (R^2=0.132) for the regression model of feedback using the factor scores. Therefore, it can be concluded this model would require finding more variables to explain the suitability better. (Table 18,

Table 19)

Table 18 Model summary for feedback with factor scores

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,363[a]	,132	,121	1,371

Table 19 Coefficients of feedback model with factor scores

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig
1	(Constant)	3,482	,109		32,028	,000
	Factor Score 1	,528	,114	,346	4,641	,000
	Factor Score 2	-,203	,134	-,113	-1,512	,133

Based on the multiple linear regression analysis, there are four variable that is useful in explaining the suitability of feedback as an intervention method at the University of Helsinki. These variables are attitude (β=0,358, $p<0.05$), extrinsic motivations (β=0,384, $p<0.01$), knowledge (β= -0,388, $p=0.001$) and perceived possibilities to influence energy efficiency (β=0,358, $p<0.05$). This is supported by the findings of the correlation analysis. However, the model does only explain a part of why feedback would be a suitable intervention method (R^2=0.273). There may therefore be many variables that were not included in this study that could predict the effectiveness of feedback. (Table 20, Table 21)

Table 20 Model summary for feedback with initial variables

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,522[a]	,273	,234	1,279

Table 21 Coefficients of feedback model with initial variables

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	,449	,913		,492	,624
	INDBARR	,144	,110	,098	1,301	,195
	ATTIT	,358	,179	,264	2,004	,047
	VALUE	-,100	,181	-,069	-,551	,582
	EXTMOT	,384	,123	,233	3,115	,002
	SOCBARR	-,100	,128	-,069	-,781	,436
	SNORMS	,110	,112	,082	,981	,328
	KNOWL	-,388	,110	-,304	-3,524	,001
	POSS	,358	,154	,205	2,323	,022

4.4.2 Incentives Regression Models

Based on the multiple linear regression analysis, neither of the two factors is able to explain the suitability of incentives. The R^2 value is also very low (R^2=0.006) for the regression model of incentives using the factor scores. Therefore, it can be concluded that neither of the factors are useful in predicting the suitability of incentives as an intervention method. (Table 22, Table 23)

Table 22 Model summary for incentives with factor scores

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,076[a]	,006	-,007	1,285

Table 23 Coefficients of incentives model with factor scores

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	2,594	,102		25,539	,000
	Factor Score 1	-,092	,106	-,069	-,861	,390
	Factor Score 2	,052	,126	,033	,411	,682

Based on the multiple linear regression analysis, there is only one variable that is useful in explaining the suitability of incentives as an intervention method at the University of Helsinki. The only significant variable is extrinsic motivations (β=0,339, $p<0.01$). This is perhaps not surprising as this was already indicated in the correlation analysis. The theoretical research of this study would also support this. However, the model does only explain a small part of why incentives would be a suitable intervention method (R^2=0.076). There may therefore be many variables that were not included in this study that could predict the effectiveness of incentives. (Table 24, Table 25)

Table 24 Model summary for incentives with initial variables

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,275[a]	,076	,014	1,271

Table 25 Coefficients of incentives model with initial variables

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	1,946	,910		2,138	,034
	CONTR	,028	,097	,029	,289	,773
	INDBARR	,170	,112	,132	1,516	,132
	ATTIT	-,047	,179	-,040	-,263	,793
	VALUE	,013	,192	,010	,067	,947
	INTMOT	-,018	,118	-,017	-,151	,880
	EXTMOT	,339	,126	,234	2,698	,008
	SOCBARR	-,035	,129	-,028	-,274	,785
	SNORMS	,093	,119	,079	,783	,435
	KNOWL	-,116	,109	-,104	-1,065	,289
	POSS	-,093	,157	-,061	-,590	,556

4.4.3 Education Regression Models

The regression model based on the factors would indicate that Factor 2 (β=0,877, p<0.001) is significant in determining whether education is a suitable intervention method at the University of Helsinki. However, the model does only explain a part of why education would be a suitable intervention method (R^2=0.301). This is, however, the model in this study with the highest R^2 value. (Table 26, Table 27)

Table 26 Model summary for education with factor scores

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,549[a]	,301	,292	1,09819

Table 27 Coefficients of education model with factor scores

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	3,278	,087		37,758	,000
	Factor Score 1	-,109	,091	-,080	-1,200	,232
	Factor Score 2	,877	,108	,543	8,141	,000

Based on the multiple linear regression analysis, there are four variable that is useful in explaining the suitability of education as an intervention method at the University of Helsinki. These variables are valuing energy efficiency (β=0,275, p<0.05), social barriers (β=0,214, p<0.05), knowledge (β=0,676, p<0.001) and perceived possibilities to influence energy efficiency (β= -0,290, p<0.01). The findings regarding knowledge being strongly correlated to the suitability of education as an intervention method is also supported by the findings of the correlation analysis. However, the model does only explain a part of why education would be a suitable intervention method (R^2=0.494). This is, however, the model

in this study with the highest R^2 value. There may still be some variables that were not included in this study that could predict the suitability of education. (Table 28, Table 29)

Table 28 Model summary for education with initial variables

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,703[a]	,494	,474	,94689

Table 29 Coefficients of education model with initial variables

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	,387	,613		,632	,529
	VALUE	,275	,110	,211	2,492	,014
	INTMOT	-,082	,085	-,079	-,967	,335
	SOCBARR	,214	,090	,166	2,391	,018
	SNORMS	,122	,083	,102	1,472	,143
	KNOWL	,676	,078	,594	8,640	,000
	POSS	-,290	,106	-,187	-2,726	,007

4.4.4 Community Based Social Marketing Regression Models

The regression model based on the factors would indicate that Factor 1 (β=0,560, $p<0.001$) is significant in determining whether community based social marketing is a suitable intervention method at the University of Helsinki. However, the model does only explain a part of why the intervention method would be a suitable intervention method (R^2=0.235). (Table 30, Table 31)

Table 30 Model summary for community based social marketing with factor scores

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,484[a]	,235	,225	,992

Table 31 Coefficients of community based social marketing model with factor scores

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	4,525	,078		57,691	,000
	Factor 1	,560	,082	,476	6,816	,000
	Factor 2	,121	,097	,087	1,243	,216

Based on the multiple linear regression analysis, there is only one variable that is useful in explaining the suitability of community based social marketing as an intervention method at the University of Helsinki. The variable is valuing perceived possibilities to influence energy efficiency (β=0,277, p<0.05). This is supported by the findings in the correlation analysis. Additionally, individual barriers can somewhat help to explain the suitability of the intervention method (β= -0,153, p=0.056). However, the model does only explain a part of why community based social marketing would be a suitable intervention method (R^2=0.235). There may still be some variables that were not included in this study that could predict the suitability of the intervention method. (Table 32, Table 33)

Table 32 Model summary for community based social marketing with initial variables

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,484a	,235	,225	,992

Table 33 Coefficients of community based social marketing model with initial variables

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	2,251	,637		3,537	,001
	CONTR	,081	,073	,094	1,121	,264
	INDBARR	-,153	,079	-,135	-1,928	,056
	VALUE	,183	,111	,163	1,647	,102
	INTMOT	,091	,088	,101	1,029	,305
	EXTMOT	-,154	,092	-,121	-1,679	,095
	SNORMS	,088	,084	,085	1,050	,296
	POSS	,277	,112	,206	2,472	,015

4.5 Summary of Results of Statistical Analysis

The variables that explain the suitability of the different intervention methods are presented in Figure 11 and Figure 12. The regression models indicate that the factors may be useful in explaining which intervention method is more effective for users that fit into one of the two factors. There also seems to be some individual variables that are helpful when trying to choose the most effective intervention method.

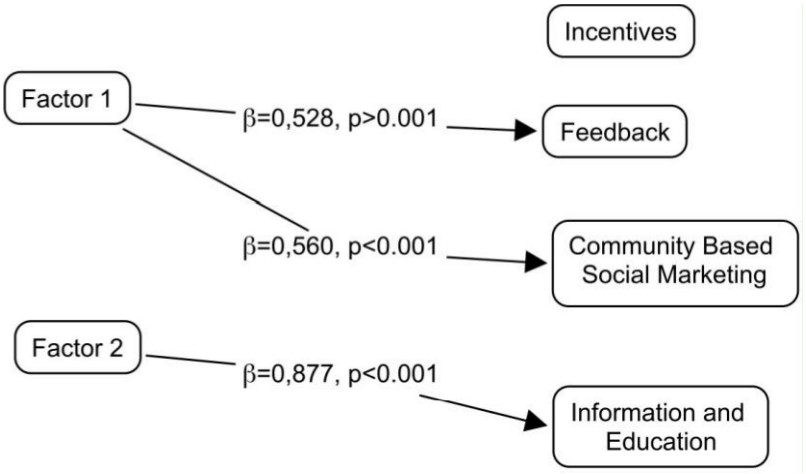

Figure 11 Factors influencing the choice of intervention methods

When observing the construct of the regression models it is clear that persons that have valued Factor 2 and its underlying variables highly (knowledge and social norms) could benefit from educational intervention methods. Similarly, those who have responded with high values to the variables included in Factor 1 (values, attitude intrinsic motivations, perceived possibilities to affect energy consumption, perceived behavioral control and negatively onto social barriers) could benefit from interventions focused on feedback and community based social marketing. All of the aforementioned connections are statistically significant at $p<0.001$, which indicates that the model presented can be very useful when choosing intervention methods at this specific setting.

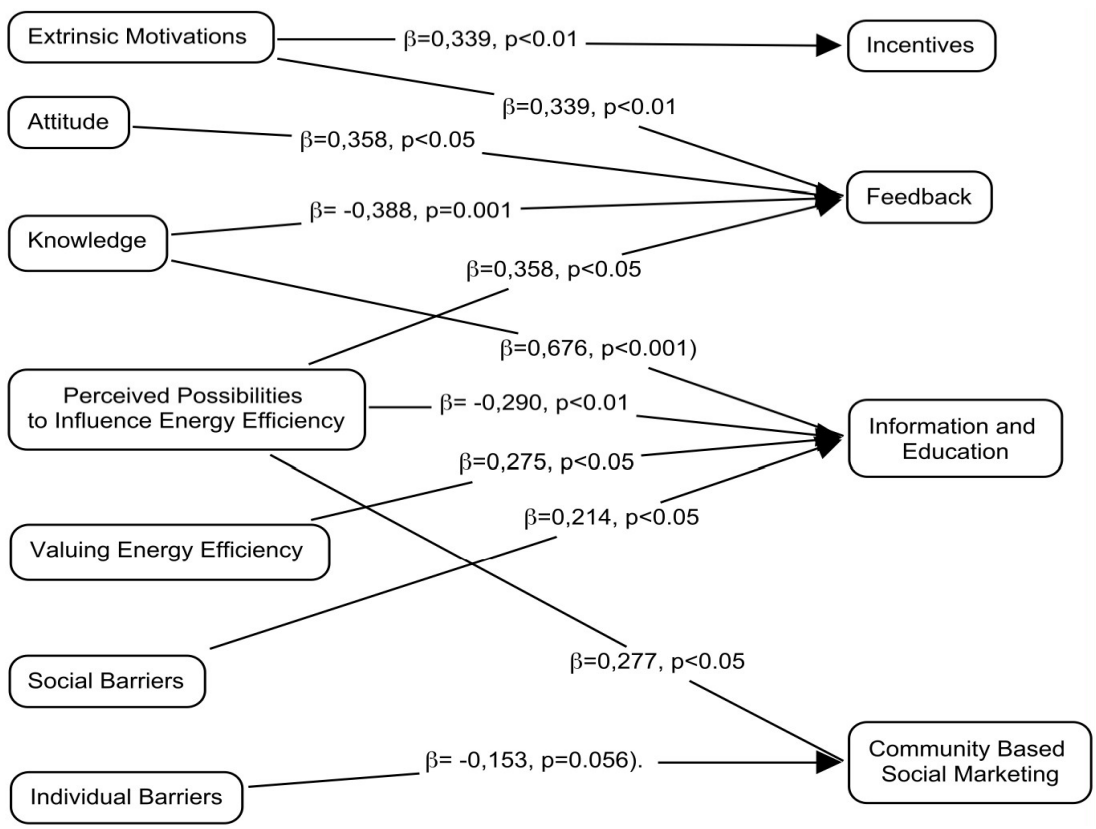

Figure 12 Variables influencing the choice of intervention methods

The most significant connections between initial variables are represented in Figure 12. The connections that are significant at $p<0.001$ can be viewed as most significant and there were some found in this study. The variable knowledge is useful in explaining two intervention methods at this significance level: education and feedback. In the general, the respondents indicated high values related to knowledge in the questionnaire, so presumably these two intervention methods are suitable at the university campus setting.

Some relationships between variables and intervention methods were significant at $p<0.01$, which also strongly indicates that these variables are important when choosing intervention methods. A noteworthy connection can be found between extrinsic motivations and both incentives and feedback. This connection is well supported by findings in the literature review.

5 Conclusions

In this chapter the conclusions of the thesis are presented, the research is evaluated and some suggestions for further research are given.

5.1 Helsingin Yliopistokiinteistöt Oy's Intervention Methods

This study would suggest that the end-users could be differentiated based on certain variables as proposed. The differences are not easily visible, but can be detected using statistical analysis. This study also found that there are many similarities among the end-users at university campuses and that some variables may not be useful in differentiating between users specifically at university campuses, also in accordance with the initial propositions regarding **RQ2**. The end-users at the University of Helsinki are somewhat homogenous, but some statistically significant differences were detected. These differences were useful in determining what factors and variables may be useful to map out before conducting an intervention at university campuses.

This study indicates that a combination of intervention methods seems to be useful at the University of Helsinki. However, there does not seem to be any need to use incentives based on the results of this study. A very small group of the respondents seemed to prefer to be rewarded for their efforts and extrinsic motivations in general do not seem to motivate the respondents at the university and as such incentives do not seem to be the appropriate intervention method for the University of Helsinki. Therefore, it can be assumed that feedback, education and community based social marketing can all be used as intervention methods at the university campus. This supports the proposition made in regards to **RQ3** that education and feedback can be assumed to be suitable intervention methods at university campuses.

The intervention methods included in this study seemed to be on quite equal footing, with education and feedback being slightly better suited in the university setting. This seems logical, as the people at the university already are interested in research and knowledge. They already have a tendency to be interested in the why and the how of reducing energy consumption and improving energy efficiency. However, the respondents tended to value their research higher than energy efficiency, which is why it is important to inform the people at the university of how they can improve energy efficiency without compromising the standards of their research.

The purpose of intervention methods is to improve users' energy consumption behavior and eliminate energy-wasting behavior (**RQ1**). By doing this, reductions in energy consumption of 0% to 20% can be reached, based on the literature review. Savings ranging from 0 MWh to 3666 MWh could be obtainable. 0 MWh would require that there would be no savings, whereas 3666 MWh would require savings of 20% in both operational and heating energy. The actual savings of interventions is likely to be somewhere in between. These reductions corresponds to savings of 0 € to 256620 € (Tilastokeskus 2014)

5.2 Evaluation of the Research

The evaluation of the research can be conducted by assessing the validity and reliability of research. Validity refers to the extent to which the study reflects the specific concept that the research is trying to measure accurately. Both internal validity end external validity should be assessed when assessing the validity of the research. Reliability is the extent to which the testing of something yields the same result if performed repeatedly. (Ketokivi 2009)

The reliability of this analysis was tested with Cronbach's alpha to test for the internal consistency of the variables used. Most of the variables yielded a high alpha value while some values were of a lower standard. Due to the complex nature of the phenomenon and the exploratory nature of the research also lower alpha values were accepted. For the variables with an unacceptable alpha value, some items were excluded in order to improve the reliability of the research. Additionally, the questionnaire was designed with method biases in mind to improve the reliability of the research. (Ketokivi 2009; Podsakoff et al. 2003) The response rate of approximately 20% and representativeness of the campus population would suggest sufficient reliability of this research (Vilkka 2007).

In general, the findings of the research seem to be consistent with the findings of the literature review. For example, both external and internal motivations influence the preference of intervention methods (Amabile 1993; Chan et al. 2012). Likewise, attitudes and other factors related to users' behavior do influence the preference of intervention methods (Ajzen 1991; Breukers et al. 2011). This study also found that some barriers to behavioral change influence the preference of intervention methods (Maio et al. 2007; Lorenzoni et al. 2007). According to a study by Greene et al (2014), there are in fact different types of personalities within the organizations, which supports the findings of this study. Greene et al.'s (2014) study also found that different methods for improving energy efficiency are preferred by different types of people, which is in line with the findings of this study. This study focused on intervention methods while Greene et al.'s (2014) study focused on energy efficiency improvements in general. As such there would appear to be a sufficiently high level of validity present in the study considering the nature of the research. Also, by mostly using previously designed questions in the questionnaire, the validity of this research was ensured. The context in which this specific study was conducted contains limited variations in the users in relation to energy efficiency, as demonstrated by the results of the questionnaire. The end-users at the University of Helsinki are quite homogenous which may limit the generalizability of the results. The model found in this study is somewhat limited due to the homogeneity of the end users at the university. (Vilkka 2007; Ketokivi 2009) The questionnaire was also pre-tested in an effort to improve the validity of the research.

5.3 Further Research

There seems to be a research gap when considering the psychological foundations of selecting intervention methods and trying to apply the most suitable intervention method for specific types of building end-users. This research has laid a foundation for the continued study of the subject. This research revealed that there are many aspects related to this field of study that need to be expanded or combined. There are studies such as Greene et al.'s (2014) that focus on the different user types and several studies on interventions, but combining the two types of studies does not really exist.

One aspect that could be examined is the addition of variables to the models found in this study. This research only used four categories of intervention methods and there are some variations of them available. Additionally, new intervention methods could be introduced or interventions used in relation to other fields could be examined. This study also revealed that there were some variables missing when exploring the suitability of different intervention methods for different user types. It would be useful to identify the missing variables. There is a possibility that the unexplained variables cannot reasonably be explained because behavior and behavioral change is a complex phenomenon. If that is the case, further research could assure that the variables discovered in this study are the main variables influencing the suitability of intervention methods.

This study was largely focused on user preferences and the users' own perceptions of energy efficiency and the intervention methods. No testing and evaluation of intervention methods occurred in connection with this study. Further research into the practical implications of choosing intervention methods based on psychology should be conducted. In other words, the theory should be put into practice and tested. A longitudinal study into the practical implications of this study could yield in further information regarding the effectiveness of the intervention methods on different types of end-users.

The final suggestion regarding further research related to the context of the research. The context of this research is limited to one university campus and different or more versatile results could be obtained in a different context. The expansion of the context of the research could result in a more comprehensive understanding of the phenomenon. In a way, the context in which this specific study was conducted contains limited variations in the users in relation to energy efficiency. The model found in this study is somewhat limited and a more comprehensive model could result in a model that could be used universally when deciding on what intervention method to implement.

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Appendix 1: Questionnaire Design

Variable	Item
Other background factors	Gender
	Age
	Role at university
	faculty
	Leadership
	Do you have a permanent own workstation at the campus building?
	Building
	How much time do you spend at the university weekly on average
	Percentages
	If you spend time at the campus between 20.00 and 8.00, what are your reasons for this?
	If you spend time at the campus between 20.00 and 8.00, would you be willing to use a designated space for night time working?
Values	Saving energy and natural resources is important to me
	I am in favor of saving energy within the University of Helsinki
Attitudes	The University of Helsinki should be concerned with saving energy
	I should help the Univeristy of Helsinki save energy
	The University of Helsinki takes energy saving seriously
Possibilities	I can help the University of Helsinki to save energy
	I can affect using lighting at the university
	I can't change the way I use equipment at the university
	When possible, I try to share equipment at the university
	Spaces at the university could be shared more then they are now
Knowledge	It is clear to me what the university is doing to save energy
	It is clear to me who is responsible for switching off the lights in common areas
	It is clear to me who is responsible for switching off research equipment during downtimes
Social norms	I discuss energy saving at work with my peers at the university

	I would be well thought of by my peers if I took actions to save energy at work
Perceived behavioral control	In my experience, it has been easy to change my behavior to save energy
	I need reminders to change my behavior in order to waste less energy
	I know how to reduce energy consumption at the university campus
Individual	Technology is the best way to reduce energy consumption
	More efficient technology is a better way to increase energy efficiency at the university than changing my behavior
	I would not reduce energy consumption at the expense of my work/studies
Social	The university does not do enough to save energy
	Society takes sufficient action to save energy
Extrinsic	Other people will get upset if I don't do my share of saving energy at the campis
	I save energy in order to avoid being criticized
Intrinsic	I take pleasure in saving energy
	I would feel bad if I did not do anything to save energy
Social mark	To me it is important to be a part of a group at the univeristy when working towards a common goal
	Saving energy as a group is effective
Incentives	Being rewarded for my efforts to save energy at the university is important to me
	Energy uses resources that could be used for something else, e.g. Research
Feedback	I am curious to know how much energy other teams/departments/groups use
	I know approximately how much energy I use at work
Education	I receive enough guidance about switching off equipment at the university
	I have received enough training on energy saving at the university
self-reported behavior	*When I leave a room/space that is unoccupied, I always turn off the lights*
	When there is sufficient natural light in the room, I always turn off the lights
	I always turn off a piece of machinery equipment/appliances during downtimes (if possible)
	I always turn off a piece of machinery equipment/appliances at weekends (if possible)
	When the heating is on, I always ensure that the windows are shut

Appendix 2: Questionnaire

Background information

***1. Gender**

- ◯ Female
- ◯ Male

***2. Age**

[ ]

***3. Your role at the university:**

- ◯ Bachelor's student
- ◯ Master's student
- ◯ Doctorate student
- ◯ Teaching and research staff
- ◯ Administrative personnel
- ◯ Library personnel
- ◯ Facility and service personnel
- ◯ IT staff
- ◯ Support personnel for teaching and research
- ◯ Teaching personnel at the training school
- ◯ Other personnel

4. Which faculty do you belong to? (teaching staff, researchers and students, if not applicable you can skip this question)

- ◯ Faculty of Biological and Environmental Sciences
- ◯ Faculty of Agriculture and Forestry
- ◯ Faculty of Pharmacy
- ◯ Faculty of Veterinary Medicine

***5. Do you have a permanent own workstation at the campus building?**

- ◯ Yes
- ◯ No

***6. Which building do you spend the most time at?**

- ◯ Biocenter 1
- ◯ Biocenter 2
- ◯ Biocenter 3

***7. How much time do you spend in the Viikki Campus buildings weekly on average (in hours)?**

[ ]

8. What percentages of the time you spend at the university do you approximately spend during the following times? E.g. if you spend all of your time at the university between the hours of 8.00 and 12.00, then enter 100 % for this option. The total of should be 100 %.

	% of the time
8.00-12.00	
12.00-16.00	
16.00-20.00	
20.00-0.00	
0.00-4.00	
4.00-8.00	

Organizational level: Views on energy consumption and energy consumption be...

Please choose the opinion that best suits you.

9. Please choose an option between 1 (I strongly disagree) and 6 (I strongly agree)

	1 I strongly disagree	2	3	4	5	6 I strongly agree
I am in favor of saving energy within the University of Helsinki	◯	◯	◯	◯	◯	◯
The University of Helsinki should be concerned with saving energy	◯	◯	◯	◯	◯	◯
The organization takes energy saving seriously	◯	◯	◯	◯	◯	◯
I can help the University of Helsinki to save energy	◯	◯	◯	◯	◯	◯
It is clear to me what the organization is doing to save energy	◯	◯	◯	◯	◯	◯
It is clear to me who is responsible for switching off research equipment during downtimes	◯	◯	◯	◯	◯	◯
I discuss energy saving at work with my peers at the university	◯	◯	◯	◯	◯	◯
I would be well thought of by my peers if I took actions to save energy at work	◯	◯	◯	◯	◯	◯
The university does not do enough to save energy	◯	◯	◯	◯	◯	◯
To me it is important to be a part of a group at the university when working towards a common goal	◯	◯	◯	◯	◯	◯
I am curious to know how much energy other teams/departments/groups use	◯	◯	◯	◯	◯	◯
Spaces at the university could be shared more than they are now	◯	◯	◯	◯	◯	◯
I receive enough guidance about switching off equipment at the university	◯	◯	◯	◯	◯	◯
I have received enough training on energy saving at the university	◯	◯	◯	◯	◯	◯
It is clear to me who is responsible for switching off the lights in common areas	◯	◯	◯	◯	◯	◯
I should help the University of Helsinki save energy	◯	◯	◯	◯	◯	◯

Individual level: Views on energy consumption and energy consumption behavi...

Please choose the opinion that best suits you.

10. Please choose an option between 1 (I strongly disagree) and 6 (I strongly agree)

	1 I strongly disagree	2	3	4	5	6 I strongly agree
Saving energy and natural resources is important to me	○	○	○	○	○	○
I can affect using lighting at the university	○	○	○	○	○	○
I can't change the way I use equipment at the university	○	○	○	○	○	○
When possible, I try to share equipment at the university	○	○	○	○	○	○
In my experience, it has been easy to change my behavior to save energy	○	○	○	○	○	○
I need reminders to change my behavior in order to waste less energy	○	○	○	○	○	○
I know how to reduce energy consumption at the university campus	○	○	○	○	○	○
Technology is the best way to reduce energy consumption	○	○	○	○	○	○
More efficient technology is a better way to increase energy efficiency at the university than changing my behavior	○	○	○	○	○	○
I would not reduce energy consumption at the expense of my work/studies	○	○	○	○	○	○
Society takes sufficient action to save energy	○	○	○	○	○	○
Other people will get upset if I don't do my share of saving energy at the campus	○	○	○	○	○	○
I save energy in order to avoid being criticized	○	○	○	○	○	○
I take pleasure in saving energy	○	○	○	○	○	○
I would feel bad if I did not do anything to save energy	○	○	○	○	○	○
Saving energy as a group is effective	○	○	○	○	○	○
Being rewarded for my efforts to save energy at the university is important to me	○	○	○	○	○	○
Energy uses resources that	○	○	○	○	○	○

could be used for something else, e.g. research						
I know approximately how much energy I use at work	◯	◯	◯	◯	◯	◯
When I leave a room/space that is unoccupied, I always turn off the lights	◯	◯	◯	◯	◯	◯
When there is sufficient natural light in the room, I always turn off the lights	◯	◯	◯	◯	◯	◯
I always turn off a piece of machinery equipment/appliances during downtimes (if possible)	◯	◯	◯	◯	◯	◯
I always turn off a piece of machinery equipment/appliances at weekends (if possible)	◯	◯	◯	◯	◯	◯
When the heating is on, I always ensure that the windows are shut	◯	◯	◯	◯	◯	◯

Views on energy consumption and energy consumption behavior

11. Give one suggestion about how to save energy on the university campus:

12. Rank the following communication channels from most effective to least effective when considering energy efficiency communication at the university (the order of the choices will change according to your selections):

- [ ] One-on-one communication
- [ ] Seminars
- [ ] Bulletin
- [ ] Social media (e.g. Facebook, Twitter)
- [ ] University web page
- [ ] Information board
- [ ] E-mail
- [ ] Intranet (Flamma)

13. If you feel some communication channel was missing in the previous question, please elaborate.

Thank you for taking the time to fill out the questionnaire!

Appendix 2: Questionnaire Cover Letter

Dear Viikki campus member,

Energy efficiency is an important issue at the University of Helsinki with not only focus on technology and building features, but also the human factor and demand of energy.

As a user of the Viikki campus you are kindly asked, by Aalto University, Helsingin Yliopistokiinteistöt Oy and Granlund Oy in co-operation with University of Helsinki Center for Properties and Facilities, to fill out a questionnaire about your energy consumption behavior and you perception about intervention methods related to the energy efficient use of buildings. The questionnaire is a part of a master's thesis research at Aalto University.

The questionnaire consists of 11 multiple choice, 2 Likert scale questions and 5 open ended question about your attitudes, motivations and general knowledge about energy efficiency goals at the university. It takes approximately 15 minutes to complete the questionnaire. The questionnaire is completely anonymous and the results will be confidential.

To go to the questionnaire, please click the link below:

(LINK TO QUESTIONNAIRE)

Please complete the questionnaire by 30.9.

For more information concerning the study:

(CONTACT INFORMATION)

If you wish to receive information about the results please let me know at the aforementioned e-mail address.

Thank you for your devotion of time to complete the questionnaire and helping us improve energy efficiency at the Viikki campus.

Sincerely,

Sara Grotell

Aalto University
School of Engineering

Granlund
Less energy gives more

Real Estate Economics

HELSINGIN YLIOPISTOKIINTEISTÖT

In co-operation with: University of Helsinki, Center for Properties and Facilities